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REVIEW of EDUCATIONAL RESEARCH

Volume V

OCTOBER, 1935

THE MICHIGAN PLANT

This issue reviews the literature up to date the Michigan Plant of the Educational Research Service, 1932, entitled, *Buildings, Groups, Equipment, Apparatus, and Supplies*.

AMERICAN EDUCATIONAL RESEARCH ASSOCIATION
NATIONAL EDUCATIONAL EQUIPMENT ASSOCIATION
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Volume V

October, 1935

Number 4

THE SCHOOL PLANT

Prepared by the Committee on the School Plant: E. T. Peterson, Don C. Rogers, W. K. Wilson, and T. C. Holy, *Chairman*; with the cooperation of William E. Arnold, Price Chenault, Thomas J. Higgins, Charles A. Lee, Francis R. Scherer, and H. W. Schmidt.

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INTRODUCTION

IN THE FIRST CYCLE of the *Review of Educational Research*, an issue dealing with school buildings, grounds, equipment, apparatus, and supplies appeared in December, 1932. That number covered the literature in the above areas up to July 1, 1932. However, in organizing this second number, effort has been made to cover the school plant field more completely than was done in the first number. To that end, certain additional topics have been included. The period covered in analyzing the literature under these additional topics extends previous to July 1, 1932, the date at which the first cycle ended. The title, "The School Plant," used for this number, more nearly fits this broadened scope than that used for the first number.

In the judgment of the writer, the most significant thing brought out by these two issues dealing with the school plant is the lack of basic research in this field. In fact, Chapter VII of this number, entitled "Types of Construction and Materials as Related to Original Cost, Maintenance, and Operation of School Buildings," has no bibliography because its writer found no research in published form on this topic. Here is an area in which there is an expenditure for construction, operation, and maintenance of approximately \$500,000,000 a year in the United States, in which little fundamental research is available. Furthermore, there is now little concerted, continuous effort to explore this important field. The last chapter in this number of the *Review of Educational Research* deals with needed research in the school building and equipment areas.

Because of this lack of basic research, coupled with the fact that the planning and construction of needed school buildings cannot be delayed until the essential investigations can be carried out, much material based on judgment and experience has been included. This, the committee believes, will be helpful to those on whom the responsibility for the development of the school plant rests.

T. C. HOLY, *Chairman,*
Committee on the School Plant.

WORCESTER.

WORCESTER. — This town lies in the western part of the county, bounded on the north by Uxbridge, on the east by Hopkinton, on the south by Mendon, and on the west by Southborough. It is situated on the Connecticut river, which flows through it in a narrow channel, and is crossed by several bridges. The town is intersected by several small brooks, and is generally a hilly country. The soil is generally light and sandy, and the climate is cool and temperate. The town contains several large and handsome buildings, and is well supplied with water and timber. The population is about 3,000, and the town is well known for its manufactures of iron and steel, and for its extensive trade in agricultural products. The town is well supplied with roads and bridges, and is easily accessible from all parts of the state. The town is well known for its manufactures of iron and steel, and for its extensive trade in agricultural products. The town is well supplied with roads and bridges, and is easily accessible from all parts of the state.

CHAPTER I

Technics for Determining Housing Requirements in Elementary, Junior, and Senior High Schools

SINCE ALL PHASES of research on the construction, operation, maintenance, and equipment of school buildings are covered in other chapters of this issue of the *Review of Educational Research*, this chapter is confined to a review of studies related directly or indirectly to the determination of the number, type, and capacity of recitation rooms needed in planning a school building. The word "recitation" is used in its broad sense to include all rooms used for any kind of educational activity carried on as part of the daily educational program.

Upward of 6,500 titles of literature dealing with school buildings were examined, including the 6,084 titles and brief descriptions compiled by H. L. Smith and Noffsinger (28) and H. L. Smith and Chamberlain (27). From this examination 76 titles were selected whose brief summaries indicated that some type of research in school building planning might have been done. Examination of these 76 books and articles revealed that 43 of them were not research projects and these were, therefore, eliminated.

Of the 33 research projects remaining, 19 were unpublished master's theses. These were not reviewed, but are listed in the bibliography as an indication of the type of school building research being carried on in the various graduate schools of education. In many instances they may serve as a basis for further needed research in some special phases of school building planning.

Analysis of the available research on school building planning showed that it could be classified into five types of studies covering the three types of buildings. The five study types involved planning technics, utilization studies, reviews of plans, school building standards, and studies on the planning, equipping, or utilization of special rooms. Table 1 (p. 338) shows the distribution of these studies according to type of study and building, the symbol "X" being used for reviewed studies, and the symbol "M" being used for master's theses, not reviewed but listed. The studies reviewed are discussed in the reverse order of the listing of types in the table.

Special Rooms

Brodshaug (2) made a highly specialized study of plans and equipment for teaching home economics in junior high schools and senior high schools in cities of populations of 10,000 to 500,000. His procedures involved a review of literature, an analysis of city standards, visitation of many home economics plants, and interviews with school authorities.

Three of his outstanding conclusions are:

1. The home economics curriculum is in a process of rapid and varied transition, and leaders are far from any agreement as to what is proper curriculum material. This condition makes it difficult to plan a suitable plant layout which will not immediately become obsolete.
2. In the schools visited the average number of pupil stations provided in laboratories was twenty-four. The junior high schools were almost standardized in this respect.
3. Thirty-five square feet per pupil was the approximate average in foods laboratories and clothing laboratories in the thirty-nine schools. This is generally regarded as satisfactory by state standards. If a demonstration area is desired in the laboratory, forty square feet is recommended.

TABLE 1.—DISTRIBUTION OF RESEARCH STUDIES ON SCHOOL BUILDING PLANNING

Types of research studies	Elementary-school buildings	Junior high-school buildings	Senior high-school buildings
Planning techniques		X	X-X-M-M
Utilization	X-M	X	
Review of plans	X-X-M	X	M-M-M
Building standards	X	X	
Special rooms	X	M-M	X-X-X M-M-M-M M-M-M-M M-M

Heywood and Rust (13), basing their judgment largely upon experience and observation, set up a list of characteristics of satisfactory home economics laboratories and classrooms, including space requirements for schools of various sizes. The research value of this contribution is doubtful. Flemington (10) and McCulloch (19) wrote master's theses on the planning and equipment of home economics rooms. Both studies were surveys of existing practices.

Green (12) studied the type, location, and space allotment of commercial rooms in 125 of the largest high schools in the North Central states. The typical commercial suite was arranged as a unit, centrally located on the second floor, and contained rooms for bookkeeping, typing, stenography, and commercial recitation. The bookkeeping room contained 640 square feet, the stenography room 725 square feet, and the typing room 690 square feet. These rooms were equipped for 36, 37, and 42 pupils respectively. The commercial recitation room was a standard unit of 660 square feet.

Soper (29) made a utilization study of the elementary-school auditoriums in New York state. According to the opinions of school heads answering the questionnaire, auditoriums located in basements or on third floors are practically useless for educational activities. No recommendations were made as to the size of auditorium in relation to the size of school. Coleman

(4), Douthirt (6), Evans (7), Lohmoelder (16), A. Smith (26), and Winters (34) wrote master's theses on some phase of the planning and utilization of auditoriums and gymnasiums.

Two theses, one by Lightfoot (15) and one by Lundgren (18), presented surveys of the housing, equipment, and materials used in industrial arts departments in the Los Angeles junior high schools and the class A schools in Kansas, respectively. Two other master's theses listed on the planning of special rooms are the one by Rowe (25) on the survey of music departments in the Bay district of California, and the one by Carnes (3) on the natural science laboratories of Florida high schools.

Building Standards

The two outstanding recent contributions on school building standards are by Strayer and Engelhardt (31) on elementary buildings, and by Holy and Arnold (14) on junior high schools. Strayer and Engelhardt have again revised and enlarged their elementary building standards originally published in 1916. The study by Holy and Arnold was based upon the consensus of opinion of experts as to what should constitute ideal housing conditions for a junior high school.

Reviews of Building Plans

Goldthorpe (11) analyzed the floor plans of 94 junior high-school buildings, 43 of which plans were published in the *American School Board Journal* in 1920-24, and 54 in 1925-29. The buildings were distributed from villages of 1,000 population to cities of 1,000,000 population. Half the buildings were located in cities of 10,000 to 100,000 population. One hundred sixty-six types of educational space provisions were found. Two-fifths of the buildings provided study halls; twice as many of the schools making such provision were above the 1,000 pupil capacity as below that capacity. The chief conclusion was that buildings planned for less than 700 enrolment were limited in the types of educational facilities provided.

Pittenger (22) analyzed 70 floor plans of elementary buildings as presented in the *American School Board Journal*. He found the classroom the only type of facility common to all plans analyzed. The tabulation of spaces was made with the buildings grouped according to number of classrooms, with 5 to 16 rooms in the first group, 17 to 36 in the second group, and 37 to 83 in the third group. Pitkin, Oberholtzer, and Strayer (21) made a similar analysis of 20 elementary building plans published in the *School Executives Magazine*. The sizes and features of instructional and non-instructional rooms were noted. Two kindergartens of special features were described, but no interpretation of data that might lead to better planning was made.

Four master's theses, by Lowry (17), Younger (35), Powers (23), and Spohn (30) have been written recently on the review of school building

plans. Lowry found 317 planning errors and 345 structural errors in six buildings. Younger made a study of the space provisions of 64 high-school building plans. Powers made a similar study of elementary- and junior high-school plans of 1910, 1920, and 1930, to determine changes and trends, while Spohn made a similar study of 24 high-school building plans of 1907, 1917, and 1927. He found rapid changes in 1927, especially in commercial and home economics rooms. Classrooms, libraries, auditoriums, physical education rooms, and shops showed less change.

Utilization

Fink (8) used a simplified form of the Morphet technic for studying the utilization of 89 elementary buildings in Minneapolis. Only instructional rooms were measured. The teacher-station utilization of buildings varied from 45 percent to 86 percent, with a median of 78 percent. Pupil-station utilization varied from 41 percent in one building to 81 percent in another, with a median building utilization of 68 percent. These percents were considered high by the author. Pugh (24) made an intensive study of the utilization of one junior high-school building. The pupil-station utilization of all instructional rooms, exclusive of auditorium and gymnasium, varied from 29 percent in the cooking room to 93 percent in one homeroom and a like percent in the study hall. The pupil-station utilization of all rooms was 65 percent. The homerooms showed a teacher-station utilization of 91 percent. Pugh's conclusion was that increased enrolment in this school will necessitate better scheduling and dual assignment of the special rooms in order to obtain more efficient utilization. Devenport (5), in his master's thesis, reported on the utilization of 22 elementary- and three high-school buildings in Utah.

Planning Techniques

Finley (9), in his master's thesis reported a study of practices of housing six-year high schools in Colorado. Mays' study (20) was on the necessity for (and lack of) efficiency in high-school building layout and arrangement. Neither of these theses was available for review.

Arnold (1) studied the better junior high schools of Ohio, obtaining from school administrators, supervisors, teachers, and janitors of those schools a consensus of expert opinion as to what facilities should be provided in a junior high school. He then prepared these results in the form of tentative standards for junior high-school buildings which he submitted to nearly a hundred architects and school building specialists who made further suggestions which he incorporated in the final report of his study. Arnold also devised a score card for evaluating junior high-school buildings in which he utilized the judgment of a large number of junior high-school principals as to the relative importance of the various features of the building and its equipment.

Wilson (32, 33), after a careful analytical study of the daily programs of some 400 high schools in New York state, ranging in enrolment from 50 to 400 in grades 9 to 12, together with a utilization study of the buildings occupied by these schools, found in that state a very high degree of relationship between the number and capacity of recitation rooms needed, on the one hand, and the enrolment of the school and the program of studies offered, on the other.

From the various detailed phases of these established relationships, it was possible to develop formulas and charts from which the optimum number and capacity of required teacher stations or recitation rooms, could be determined quickly for any high school of 50 to 400 enrolment, when the desired educational program was known.

Two assumptions underlie these findings:

First, it was assumed that all special recitation rooms in a high school, with the possible exception of the boys' vocational arts rooms, could be so equipped as to be usable for certain types of non special recitations when not in use for the special recitations for which they were set up.

Second, it was assumed that in a small high school it is neither economically sound nor educationally necessary that all the recitations of a given subject, as English, or mathematics, be taught in a room set apart for that subject alone, but that with proper equipment such non-special classes may be taught interchangeably in rooms best fitted to the size of the class reciting.

Throughout this study, rooms designed specifically to house non-special classes were called interchangeable stations, and rooms designed to house special classes were called special stations. These were the homemaking, shop, agriculture, science, typing, art, and music rooms, and the library or combined study hall-library.

The findings of this study, made applicable to the planning of a high-school building in New York state were summed up as follows:

1. High-school enrolment is so closely related to the number of daily classes and daily interchangeable classes to be expected, that the number of daily interchangeable recitations approximates very closely the formula

$$\frac{\text{Enrolment}}{8} + 12 = \text{Daily Interchangeable Recitations.}$$

2. The number of interchangeable stations needed for a given enrolment can be determined by dividing the number of daily interchangeable recitations by the number of daily recitation periods, or,

$$\text{Interchangeable Teacher Stations} = \frac{\text{Daily Interchangeable Recitations}}{\text{Daily Periods}}$$

or,

$$\text{Interchangeable Teacher Stations} = \frac{\frac{\text{Enrolment}}{8} + 12}{\text{Daily Periods}}$$

A school of 240 pupils operating on a six-period day would require

$$\frac{240}{8} + 12 = \frac{42}{6} = 7 \text{ Interchangeable Stations.}$$

3. Due to the wide variation of class sizes in interchangeable classes, it is possible to conserve space and increase the percent of utilization of a building by varying the size of interchangeable stations. Basing a decision on structural limitations and current educational practices in class sizes, it was found best to set up three sizes of interchangeable stations, based upon 16.5 square feet per pupil station: small, or 20-pupil station rooms; medium, or 30-pupil station rooms; and large, or 40-pupil station rooms. Analysis of the daily recitation schedules of all schools gives the distribution shown in Table 2 as the optimum.

4. The optimum capacity of special stations was found to be closely related to the size of the school and the type of subject. Table 3 gives the recommended number and pupil capacity of various special rooms according to the size of the school.

TABLE 2.—DISTRIBUTION OF INTERCHANGEABLE TEACHER STATIONS,
AFTER WILSON (32, 33)

Stations	Small (20-pupil)	Medium (30-pupil)	Large (40-pupil)
3	1	1	1
4	2	1	1
5	2	2	1
6	2	2	2
7	3	2	2
8	3	3	2
9	3	3	3

TABLE 3.—DISTRIBUTION OF SPECIAL STATIONS, AFTER WILSON (32, 33)

Subject	Enrolment 9-12	Teacher stations	Pupil capacities of teacher stations
Science	50-88	1	Combination room .. 30
	89-200	1	Combination room .. 35 to 40
	201-400	2	{ Advanced science .. 24 to 30 Elementary science .. 35 to 40
Homemaking	50-145	1	16
	146-400	1	24
Vocational shop	50-145	1	16
	146-400	1	24
Vocational agriculture	50-145	2	{ Shop 16 Shop recitation 20
	146-400	2	{ Shop 24 Shop recitation 24
Typing	50-128	1	15
	129-184	1	20
	185-296	1	24
	297-400	1	28
Drawing or Art	50-200	None	
	201-400	1	28
Music Dramatics	50-400		{ Combination with Auditorium or Cafeteria

5. An analysis of all study-group sizes for one week in 227 high schools showed the required number of permanent study stations, as customarily provided in the study hall and library, to be as follows:

For an enrolment of 89 to 145, $\frac{1}{2}$ of the enrolment

For an enrolment of 146 to 200, $\frac{3}{4}$ of the enrolment

For an enrolment of 201 to 400, $\frac{1}{3}$ of the enrolment.

Summary

Almost daily contact with superintendents, principals, and architects coming to the School Buildings and Grounds Division of the New York State Education Department for assistance in school building planning, has convinced the writer that the type of research found in that field has been of little value in setting up a room schedule for a new building.

Practically every writer in the field admits that buildings should be planned to house the educational program. With this assumption as basic, it would seem that research in school building planning, on the educational side, should start with studies of the educational program, and not with status studies of buildings *not* scientifically planned, nor with utilization studies of such buildings. A superintendent may gather together all the school building score cards, reviews of published plans, utilization studies, or school building standards now in print; but if he is faced with the necessity for providing his architect with a room schedule for a cosmopolitan high-school building to house 2,000 pupils in grades 9 to 12, such literature will be of little help to him. That type of research has been very valuable in pointing out the need for planning technics based upon a thorough knowledge of the relation of the educational program to building needs.

Wilson's study is now being extended to four-year high schools of 400 to 3,000 enrolment. Already, through the study of 212 programs of such schools, constant relationships between enrolment and the number of special and non-special classes have been discovered. These are proving of inestimable value in determining the total number of recitation rooms required for a school of given size. Further study will determine the optimum capacities of these rooms, the number and capacities of rooms of various types needed, the number of study stations necessary, etc. Data are already collected and in the process of tabulation for making similar studies for junior high schools in New York state.

CHAPTER II

Heating, Ventilation, and Sanitation in School Buildings

Heating and Ventilation

IN THE FIRST CYCLE of the *Review of Educational Research*, the subjects of heating and ventilation were not treated in a separate chapter in the issue on school buildings, and were mentioned but briefly. The importance of the subjects, however, has led to a more extended treatment which will be covered in this chapter. The bibliography will be limited to include, with a few exceptions, material presented since 1910. This will cover, with some earlier references, the major part of the research field. As there is a bibliography record in excess of 400 titles since 1910, no effort has been made to refer to all of them; only those which seem to have a definite and major bearing upon the progress of the subjects to be discussed will be reviewed herewith.

The subjects of heating and ventilation or air conditioning, as it is now frequently called, have nearly always been discussed as a whole; this is only natural, as the two are quite intimately related—heating will always give rise to a change in air conditions, but heating alone will not produce conditions always conducive to healthful surroundings. Again, the problem of heating alone, i.e., to provide, by means of certain apparatus, certain temperatures in enclosed spaces, has been very well solved, even twenty-five years ago, through theoretical and empirical investigations. The major progress here has been in the direction of new devices and refinements of data and installations. But the problem of providing air conditioning is still in a state of flux. Therefore the greater part of this chapter will be devoted to the subject of ventilation or air conditioning. As a rule, the former term will be used for convenience and brevity.

Importance of ventilation—The effect of air and temperature upon the human body has been recognized for ages and reference to it has been an outstanding factor in virtually all literature dealing with human health. But it has been only comparatively recently that any attempt was made to explain, by various theories, the effects and influences of air conditions on the human body.

Probably the first authentic report on the effect of air conditions on the human body is that dealing with the historic tragedy of the Black Hole of Calcutta where only twenty-three of one hundred forty-six Englishmen survived the ordeal of twenty-four hours' incarceration in a room housing comfortably only two persons—an area of eighteen square inches per person (179:2). Jarvis (144:168), a physician, in commenting on the laws

of health, referred to this tragedy and applied the principle of air stagnation to explain the "faintness and languor" resulting in crowded spaces. The second historical episode was that of the *Londonderry* disaster where a large group of passengers on the ship were forcibly confined in a small cabin below decks during a storm (179:2). Similar conditions to those of Calcutta prevailed and the outcome again was death to large numbers. On the other hand, Dr. Trudeau, who was afflicted with tuberculosis in 1873, isolated himself in the Adirondacks and through the fresh air treatment recovered his health. "The general value of fresh air . . . has been amply demonstrated" (179:3).

Early theories—The first milestone in the attempted analysis of the factors and conditions which influence human health through contact with the air or atmosphere was passed by Lavoisier in 1777 when he studied the effect of air in crowded quarters and attributed it to an excess of carbon dioxide rather than a lack of oxygen. A translation of his findings, according to Leblanc (153), is of interest:

The carbon dioxide theory—Thus Lavoisier did not hesitate to attribute to carbonic acid the discomfort that was found in numerous assembly halls, discomfort generally attributed to heat alone; he established, by experiments made upon animals (confined) in a limited amount of air, that the effects observed were to be attributed to the . . . action of carbonic acid in quantities insufficient for asphyxiation and not to a (reduction) of the proportion of oxygen, if it did not fall below a certain limit.

This theory seemed to have been held in much esteem during the next hundred years; it was accepted with little question. In 1857 Bernard (62) reaffirmed this belief in definite terms and was quoted as stating "that the breathing process vitiates the air to the extent that it will render the air poisonous unless carried off by ventilation." Even in 1910, in a handbook for engineers by Hoffman and Raber (128:19), the statement was made that carbon dioxide is diffused through a room and makes the air unfit for breathing (210:57). Earlier textbooks of physiology and hygiene have always given undue prominence to the deleterious effects of carbon dioxide and even as late as 1910 mention is made of the poisonous gas carbon dioxide which we exhale in breathing (196). Yet Leblanc (153) in 1842 showed conclusively that a person may breathe air which contains 30 percent carbon dioxide and yet recover. "Il est un asphyxiant pas un poison."

The organic poison theory—The second milestone on the road to progress was reached by Pettenkofer in 1863. In his article, "Ueber die Respiration," he (183) stated as a kind of conclusion of his work, the following:

What makes the air in a room filled with people obnoxious and (depressing), what affects our nerves and gives rise to symptoms (of dizziness) leading eventually to fainting, is not only the heat or humidity or the CO₂ of the air nor the depletion of oxygen—such an atmosphere appears to us as foul and nauseous long before it becomes saturated with water vapor or depleted (in a measure) of its oxygen content, or with a CO₂ content in excess of one percent. It (the air) seems to us obnoxious

due to its having been breathed several times or as it has come into contact with the skin numerous times, as it is thus laden with organic exhalations, even in (minute) quantities.

Pettenkofer thus appreciated the problem as a whole but could not determine all of the factors involved and so he attributed much of the effect of "vitiated" air to "anthropotoxin" and "morbific" matter—body effluvia or organic poisons which gave rise to toxic effects. Thus the organic poison theory was brought into being.

Like many others the carbon dioxide theory was of the die-hard kind. Even Pettenkofer utilized the percent of carbon dioxide as an indicator. Many investigators of the next four decades after Pettenkofer's pronouncement spent a good deal of time in following up the latter's work and apparently discovered these organic poisons in exhaled air (110, 191). But the greatest adherers to this theory were Brown-Séquard and d'Arsonval. These collaborators (67) reported positively on a series of laboratory experiments and claimed to substantiate the organic poison theory. Immediately their work was challenged by Italian (202), German (192), English (108), and American (63) investigators, and all, without exception, reported negative results when repeating Brown-Séquard's experiments. Apparently the original technic was faulty.

That an odorous, bad-smelling air, usually designated as foul, is objectionable, is of course true; but it is not the poisonous effect that is to be shunned but rather the inhibiting effect of the physiological or rather functional reaction of the human organism. This gives rise to nausea and bodily discomfort, which in turn affect the involuntary muscular system of the body and thus makes breathing labored—but there is no poisonous effect, primarily (210:58).

The situation at the end of the nineteenth century was summed up by Billings and others (63) when they stated that the investigations made up to that time provided few if any facts fundamental to our then theory and practice of ventilation.

The contact-infection theory—One result of the organic poison debacle was the growth of the contact-infection theory among medical men and others. The older air-borne infection theory (disease germs floating in air, as spreading medium) was closely allied to the organic poison theory and furnished fuel for the contention of *large air volumes as combating disease*—the ventilating angle (129). Investigations by Baskerville (51), Fluegge (99), and others have shown the fallacy of this contention and today the contact-infection theory holds sway. The effect on ventilation practices is evident.

Modern theories—Among the five changes produced by human occupancy in a closed space (164:16), three have been generally discredited as being important or having any major influence upon health: increase of carbon dioxide, decrease of oxygen, and "organic effluvia." The other changes—increased temperature and humidity—had been recognized by Pettenkofer (183), but he did not give them much importance. It was

Hermans (122) who, in 1883, when repeating Brown-Séquard's experiments, called attention to the role played by both temperature and humidity in the drama of ventilation. "The problem of ventilation in this respect (temperature and humidity) is large enough without it being necessary to drag in an accumulation of hypothetical foreign air substances. . . . It is easier to do justice to the problem if it is clearly stated what is to be accomplished through ventilation."—(Translation.) A number of investigators took up the problem which culminated in Fluegge's epochal experiment and findings (99) at Breslau in 1905. In conjunction with several of his pupils and co-workers he placed individuals in air-tight cabinets (Kasten) for several hours and found they suffered no discomfort provided the temperature and humidity were reduced to normal. The temperature was then raised to 24°C (75°F) and the relative humidity allowed to rise to 89 percent while the carbon dioxide content reached 1.2 percent. In this instance the person became "unwohl" (uncomfortable). The experiment was repeated with the modification that the person could breathe the comparatively pure air outside the cabinet. Discomfort persisted but became negligible when the inside temperature was reduced to around 62° F. A fan, stirring up the inside air, also contributed to a feeling of comfort. Fluegge (99:389) said, in conclusion:

Numerous refined check methods and experiments, on both healthy and sick persons, with due consideration of thermal conditions, have shown that the chemical changes in the air due to gaseous emanations from humans have no deleterious effects upon their health.

If, in closed rooms occupied by people, certain (functional) disturbances . . . manifest themselves, these disturbances are to be attributed (solely) to heat stagnation.

The (thermic) conditions of our surrounding air—warmth, humidity, motion—are of decidedly greater importance to our health than the chemical composition of the air.—(Translation.)

This is our third milestone of progress.

These vital experiments were repeated by Benedict and Milner (58) of the United States Department of Agriculture in connection with some studies on metabolism, and their conclusions were identical with those of Fluegge. The authoritative acceptance of this theory was given by L. Hill and others (127:92), who said, in part: "Heat stagnation is therefore, the one and only cause of the discomfort. . . . The moisture, stillness, and warmth of the atmosphere are responsible for all effects and all efforts . . . should, therefore, be directed toward cooling the air . . . and the bodies of the people by setting the air in motion. . . ." This thermal theory has been the backbone of our present ventilation practice.

The whole problem has simmered down to the facts that "our thermal theory requires, among other things, air motion sufficient in quantity and low enough in temperature to dissipate the heat of metabolism at approximately the rate of its production; to remove body moisture at a rate sufficient to promote ready evaporation without actual chilling; to utilize an

air velocity which will accomplish this without drafts and of a volume which will balance all of the factors with due attention to economy" (210:59). Allen and Walker (38) estimate the heat of metabolism at from 240 to 600 British thermal units with 250 British thermal units as a median for children; this means 4.2 British thermal units per minute—a very appreciable quantity. Duffield (89:65) gave similar data in tabular form and stated, "Heat losses by evaporation do not enter into the ventilation problem," but those of convection do. Taking also into account the need for a material amount of moisture to be dissipated (210:64), and we have a practical problem before us which has not yet been solved completely. The American Society of Heating and Ventilating Engineers (43:335-40) has contributed some accurate data on these factors.

Recent studies—The first extensive and practical study of school ventilation was made by the Chicago Commission on Ventilation in 1910-13 (78). A large scale experiment was carried on in the Chicago Normal College and the report carried, among many others, the following resolutions:

Resolved, That the maximum temperature for a schoolroom, artificially heated, should not be more than 68° F.

Resolved, That the relative humidity of a schoolroom, artificially heated, should not fall below 40 percent.

Resolved, That in the present state of knowledge and practice the quantity of air supplied to schoolrooms for ventilation should not be less than 30 cubic feet per pupil per minute.

Resolved, That in the present state of knowledge it is impossible to designate all harmful factors in or associated with expired air.

This report and also a later revision (126) has been widely quoted (77, 179), but was probably not considered either as sufficiently accurate nor extensive enough to make the findings authoritatively acceptable. Quoting from the famous New York Commission's report (179:13), we find that

The extent and gravity of the effect upon the human body of an overheated atmosphere were still hard to estimate; and the possibility of certain subtle minor influences of chemical vitiation could by no means be excluded. It seemed important therefore to attack the whole problem *de novo*, since it was obviously impossible to make an intelligent appraisal . . . without a clear idea of the exact physiological criteria by which ventilation should be judged.

It might be said here that the "chemical vitiation" factor has not been considered proved or of any real significance. "The chemical constituents of the stale air of an unventilated room, vitiated by human occupancy, exert no detectable influence upon a wide series of physiological reactions" (179:86).

The New York State Commission on Ventilation (179) was appointed by the governor of the state of New York in 1913 and had been in existence and functioning until its final report in June, 1931 (178). Its major work was presented in a large and extensive report in 1923. In 1926 the Commission was reconstituted and again supported by the Milbank Memorial Fund.

Its findings and conclusions were in some instances rather revolutionary and gave rise to much discussion. As these conclusions are fundamental and accepted by many, they are briefly summarized from the final contribution of the Commission (178:16-22):

1. The conclusion of Hermans, Fluegge, Hill, and Benedict—that overheating is the primary factor in bad ventilation—was confirmed.
2. With certain thermal conditions the presence of chemical vitiation, with CO₂ content up to 66:10,000 produced a slight effect upon physical work and appetite, but no other reaction.
3. Overheating produced marked physiological changes.
4. High moisture content aggravated the effect of high temperature, but low humidities "had no perceptible influences and could not be subjectively detected by the subjects exposed to them."

The practical schoolroom studies brought out the facts that:

1. The ventilation of schoolrooms by windows alone was highly unsatisfactory.
2. A system of window gravity ventilation with air admitted over slanting window boards and tempered by radiation with gravity exhaust ducts proved highly satisfactory.
3. The conditions necessary for successful use of this system were stated essentially as follows: (Here follow six rather important conditions).
 4. As to humidity, "the unhumidified rooms were much more agreeable."
 5. Recirculation of schoolroom air (washed) had no harmful effects but it was found difficult to avoid objectionable odors.
 6. The choice of systems appears to be between a plenum system and window ventilation.
 7. The "atmosphere of the window-gravity rooms was more agreeable than that of the plenum rooms." (A subjective judgment.)
 8. "Absences due to respiratory illness were slightly greater and respiratory illnesses among pupils in attendance were markedly greater in the plenum rooms."

The report led to much discussion and debate and some of the findings were attacked vigorously. Ittner (141) showed that there was no economy involved in window ventilation and that other factors operated in a derogatory manner. Schmidt (209) commented in a similar manner while Duffield (87) entered objections to certain phases of a check experiment by Butsch (68). In a like vein E. V. Hill (125) and Challman (75) discussed the ventilation "controversy." Berestneff (60) reported a test of six systems with the mechanical ventilation most effective. On the other hand Winslow (239), who was chairman of the New York Commission on Ventilation, vigorously defended the conclusions in all respects; similarly the American Medical Association (232) went on record favoring window ventilation in particular. An article in the *Sheet Metal Worker* (45) gave "a wind-activated system" full credit for satisfactory operation. Butsch (68), in reviewing the results of the experiments of the New York Commission in Maywood, Oak Park, and Forest Park, Illinois, came to the conclusion that window ventilation was more healthful than mechanical ventilation, using absence due to respiratory diseases as a criterion. But again Duffield (88:15), who, by the way, was executive secretary and director of the field studies of the New York Commission, opposed the

findings as at all conclusive or scientific in the following brief statement:

There is . . . evidence that the attitude of those members of the Commission who were interested in this phase of the work, had changed from one of pure research to that of the propagandist, who searches for facts to support his thesis and generally ignores all others. . . . Certain members had evidently become converted to the "fresh air" theories and they ignored evidences that did not tend to support those theories.

As the criterion of respiratory diseases has been used quite consistently it is of interest to note the validity of it in the various studies made. Duffield already has criticized it. Winslow and others (241:198) stated: "The criterion of respiratory disease illness among pupils in attendance at school is dependent upon a highly subjective factor of judgment on the part of the observer. Such observations in the absence of better objective standards than we now possess are of limited value if made by a different individual in each school." This observation is repeated in another study by the same authors (240:241). But at the same time they used the same criterion, "balanced," in coming to this conclusion:

"A comparison of schoolrooms ventilated with unit ventilators (fan units) and of those ventilated by window inlets with gravity exhaust shows that the simpler gravity process is quite as satisfactory from the health standpoint as is the system involving the use of fans." The whole matter of window versus fan ventilation was set forth in the New York Commission's report in great detail.

The controversy involved is not yet settled, and was to be determined by a control experiment in Rochester, New York, but funds were lacking and no agreement was reached on the research personnel.

Methods and air supply—The three fundamentals of ventilation—temperature, humidity, and air movement—have been accepted universally and efforts have been made to devise apparatus which would achieve these conditions efficiently and economically. The manner of distributing air in schoolrooms up to about 1918 was either by a blast system (central fan or plenum) or by gravity, while heat losses and tempering of the air were taken care of by either a furnace (hot air) or boiler (steam).

About 1918 there came upon the market the unit heater which was originally developed by the Herman Nelson Corporation (120) of Moline, Illinois. It is a self-contained, steam heated unit, with a fan (blast) and is located in each room to be ventilated; it has a direct outside air inlet. In its wake there followed other ventilators of a similar type. They found much favor among those interested, as they had certain claimed advantages over the more commonly found central systems, such as the fact that "no ducts are required except small vents. . . . It is flexible. . . . It is also supposed to diffuse the air quickly. . . ." (210:64).

Around this same time, 1918, the matter of the amount of air per pupil required, especially "fresh air," came to the fore. The "30-feet-per-minute-per-child" standard was developed quite early by Pettenkofer and others, and was based on a formula to prevent the air from having a carbon

dioxide content in excess of 6 parts in 10,000 (239:91); the discarded carbon dioxide theory was still basic. On the other hand experiments by Bass (53) showed satisfactory results with an air volume of only 8.9 cubic feet, "supplied through special ducts near the face of each pupil." Similarly he (54) recommended 100 percent recirculation with ozone. The New York Commission on Ventilation (179:528) and McLure (164: 23) reported that "no evidence based on scientific research has been found during this investigation to justify the standard for classrooms of 30 cubic feet of air per minute per pupil." Berestneff (60) reported investigations which recommended 9 to 15 cubic feet of "fresh air" and velocities between 100 and 200 feet per minute, much lower than found in American practice. Nesbitt (175) claimed 27.5 cubic feet per minute per pupil for high schools and 23 cubic feet for elementary schools.

Larson's study (152) on recirculated and washed air was a rather extended one and led him to some pertinent conclusions from which are quoted the following: "The tests showed that it is both unnecessary and uneconomical to supply large volumes of air to obtain good ventilation." He also stated "that 15 cubic feet [per minute] per student would be ample providing it enters the room at a fairly high velocity and carries the proper amount of moisture." As to temperature he said that with humidity ranging from 50 to 70 percent occupants of rooms are perfectly comfortable at a temperature of 65 degrees or even less. He also felt that "ventilation by recirculation is both efficient and economical." The American Society of Heating and Ventilating Engineers (44) recommended an air volume of 30 cubic feet per minute with 10 cubic feet of outside air, among other things.

Winslow (239:109) called attention to the fact that "the diminished aeration seems to be unobjectionable," this statement based upon the fact "that the air change (in window ventilation) . . . falls materially below the 30 cubic feet." On the other hand he (239:95) said: "Under certain conditions the standard of 30 cubic feet per minute may very well represent the true needs of the situation"; he (239:96, 97) referred also to the fact that "in an interior auditorium, however, it is clear that an air supply of at least 30 cubic feet per capita per minute will be urgently required," and that "a system may be entirely adequate which supplies 10 cubic feet per minute if the temperature be properly regulated." So far there has been no pronouncement as to what is actually required in the way of air supply.

Then we have Redway (193:36) who, speaking of fallacies of mechanical ventilation, said, that it "assumes that air in classrooms is thoroughly impure and vitiated, but if the air is moving all the badness is taken out of it. A more idiotic notion could not be conceived." In a semi-editorial way an article stated that 30 cubic feet per minute (fresh or recirculated) air is too much; "only when the outdoor temperature reaches 55 deg. F. will 30 cubic feet of fresh air per minute be required to keep the temperature . . . from exceeding 66 deg. Fahr." (133:128). Schmidt (210:64-65) summed up this situation, in part, as follows:

It goes without question that the cost of operation is a big differential depending whether 10 c.f.p.m. or 30 c.f.p.m. per person are involved. . . . We have both extremes present. . . . One side claims . . . no particular inlet for outside air is required; that air movement is the only essential and that infiltration will supply all that is needed for diffusion purposes. . . . On the other hand we have the fresh-air minded who claim that even 30 c.f.p.m. . . . is none too much and that the more we get, the better. . . . Between the two extremes there is of course a reasonable middle ground. We do know that 30 c.f.p.m. . . . is not an actual necessity; and there are quite a number of unbiased minds who would reduce this to a much smaller amount. . . .

Strayer and Engelhardt (219) also gave an overview of the whole problem. Schmidt (206:59), basing his statement on years of field investigations, said that "results in practice . . . lead me to the conclusion that a much smaller supply of air . . . than required by law . . . is sufficient."

Since about 1929 the term "air conditioning" has been frequently used and in some of the technical literature has displaced the term "ventilation." E. V. Hill (123:7) said: "We like to define air conditioning as the science of modifying and controlling the air in buildings, so as to make it in the highest degree suitable for the use of mankind. Naturally this includes heating, cooling, cleaning, humidifying and all the other various processes necessary to make air suitable in the highest degree for normal human body requirements."

The factor of cooling and the fact that apparently no definite amount of outside (fresh) air is necessary has been seized upon and used in the form of a unit ventilator which employs the theory of "thermal balance" to provide air conditioning in schoolrooms (121). The problem was worked out uniquely in that the outside air is used as a cooling medium; when the temperature reaches a predetermined point the unit admits outside air for the time and in a quantity sufficient to maintain the temperature desired. It will be appreciated that the unit operates its fan continuously, thus providing the desirable air motion or "turbulence," but introduces variable amounts of outside air. A critical study of an installation was made by Schmidt (211:29) who stated "that the system produces good air conditions and operates in a satisfactory manner." The system of course violates many state codes and preconceived notions. At the same time it is in substantial accord with modern thought and trend.

At about the same time Nesbitt (175) reported the result of applying a similar principle to an installation of unit ventilators where he showed satisfactory results with variable quantities of outside air. The difference between the two principles lies in the fact that the Nelson theory uses variable amounts of outside air, tempered by recirculated air, for cooling, using auxiliary radiation as may be required; the Nesbitt scheme tempers the incoming air to a constant 60 degree temperature within the unit itself, relying upon this air to cool the air—on the theory that temperature differences between incoming and room air in excess of 10 degrees produce drafts. "Syncretized" air is the name applied to this principle (176).

Scherer (203:51) did some experimental work which combines unit ventilation with window ventilation; this combination had the advantage that "the flexibility of control takes care of ventilation under all weather conditions." But "the open window ventilation should not be used at the same time the mechanical ventilation is in operation. . . ."

At present the practical results of air conditioning are based in a great measure upon the criterion of the "comfort chart" developed and sponsored by the American Society of Heating and Ventilating Engineers (43: 323) which shows the relation between dry and wet bulb temperatures as lying in the "comfort zone." In contrast to this scientifically prepared criterion we have Watt's attitude (236), who spoke of the "American dry rot" and "steam heated women" and gave a final statement that "no ventilating system is good when the persons subjected to it do not like it," based on subjective judgments.

McConnell and others (161) showed that the influence of temperature and humidity may be readily determined in an objective manner by charting both pulse rate and systolic heart pressure and "the effective temperature is the only true index of physiological reaction and comfort." The reliability of the dry bulb temperature is thus questioned, at least in the above respect.

A study by Houghten and Yagloglou (132), very complete and analytical, showed the effect on various classes of individuals of different temperatures and humidities. Apparently quite low temperatures and high humidities are within the range of the comfort zone.

The open window controversy is still *en règle* and it is not likely that it will be settled either one way or another soon. One large school in Hartford, Connecticut, is equipped for this type of ventilating and appeared to be "fairly satisfactory" according to a personal report (to the writer) but, "it needs careful attention." On the other hand, C. A. Eddy (90) reported on an experiment in Detroit in which the results have been "disappointing." Respiratory diseases, the main health indicator, increased and on complaint of the teachers the experiment was discontinued. The American Society of Heating and Ventilating Engineers (81:104) made a plea for air conditioning based on health and not economy and restated that children in "open air schools" are far healthier "than those housed in the best buildings having modern systems of ventilation." E. V. Hill (124) again said, "The best in ventilation is unattainable without mechanical devices," and Butsch (69:133) admitted that "under the conditions of the present study there was no significant difference between the percentage of absence due to respiratory diseases in rooms operated on an approved type of fan-gravity ventilation and that in rooms operated on an unsatisfactory type of window-gravity ventilation." So for the time being, the matter must rest until authoritative data are produced.

Ozone in ventilation—One can hardly leave the subject of ventilation without at least touching upon ozone as a factor.

Probably no school system in the country has used ozone to the extent that it has been used in St. Louis. Hallett (109:50) stated that "ozone destroys all odors resulting from respiration, bodies, clothing of children. It produces mild exhilaration resembling sea breezes. . . . It reduces weight in persons corpulent from non-activity." Recirculated air is treated with "new" air and ozone. Robb (198) also approved of ozone as a vitalizing factor, but warned against undue concentration. Keiser (146:51) made a plea for using ozone on the basis of economy, claiming 37.5 percent fuel reduction by recirculating 50 percent of ozonized air. Hartman (115), Milligan (170), and Franklin (101) also mentioned and spoke for it, with, however, certain debatable factors involved.

On the other hand the New York Commission (179:503) stated that "the ozone appeared to give no relief from odor and in fact seemed to make things worse by superposing the odor of ozone upon the body odors." The *Guide* of the American Society of Heating and Ventilating Engineers (43:333) reported in a similar vein, "The value of ozone in recirculated air has been greatly exaggerated in the past . . . ozone in concentration permissible in air conditioning work exerts practically no effect on pathogenic air-borne organisms and does not destroy the source of odors. Ozone, however, masks odors by olfactory compensation." And finally we find Feldman (97) who gave positive evidence that body odors are destroyed. He intimated that the ozonizing of the air produces ionization which might be responsible for the effect. He also approved 100 percent recirculation with ozonizing and washing. Rosenow's study (200) on partially sterilizing air is of interest.

Sanitary Conveniences

Hand-washing facilities—This feature of a national health program did not receive much attention at the hands of investigators until the latter part of the 'twenties, though some slight reference to the matter had been made by Pleins (186) in 1910, who gave some standards of installation for lavatories. It was left to Thomas (226) to study the plumbing needs of schools and to give criteria for determining standards. At about the same time the School Health Bureau of the Metropolitan Life Insurance Company, under the direction of Turner (228), made a special study of hand-washing facilities in schools. The study was made in 404 schools mainly by the questionnaire method. The results were tabulated in a factual manner, but no particular criteria were either set up or applied except in the section on "extent of hand-washing facilities," in which case 72.6 percent, 35.5 percent, and 10.5 percent of the schools reporting met the standards of the American Child Health Association (41), the Massachusetts Institute of Technology (167), and Wood and Rowell (246), respectively. Evidently the use of the equipment is another matter, for "meanwhile it is a matter of administrative responsibility to use the present equipment to best advantage" (228:14). The report recommended additional problems to be the basis of further research.

Schmidt (207), in 1929, made a functional study of sanitary conveniences in Wisconsin schools, including hand-washing. He found that girls used the lavatories somewhat more frequently than boys, but also found the number of fixtures much below that required and advocated by others, even being below that of the American Child Health Association of 1:80. The lack of functioning was also well expressed by one superintendent, who said, "Well! I had no idea that our children were not carrying out the principles and dictates of our teaching. I had better look into this" (207:164). The writer (207:56) also stated, "The use of lavatories is often restricted by an undue use of mirrors suspended above them. A replacement of mirrors elsewhere will 'release' a lavatory for legitimate use," and "The absence of soap and paper towels nearly always restricts the use of lavatories." He recommended one lavatory for every two toilet fixtures.

Turner's study (228:14) resulted in an investigation along recommended lines by the Cleanliness Institute (79) in 1931; the work covered 145 schools in fifteen states. The study disclosed conditions similar and equal to those found by Schmidt (207). It also gave some interesting data on soap and water consumption, showing extremely large variations in both. The study emphasized the importance of the views of the administrator in these respects.

Tappan (225) again emphasized the necessity for personal cleanliness and called attention to the non-use of even the inadequate equipment furnished. The necessity for keeping this type of equipment in a sanitary and useful condition was stressed by numerous writers such as Dresslar (85), Garber (106), Broady, Ireland, and Miller (65), Engelhardt, Reeves, and Womrath (94), and the Metropolitan Life Insurance Company (169).

Strayer and Engelhardt (220) gave the number of lavatories as one for every fifty pupils, as a standard, while Schmidt (207) recommended one lavatory for every two toilet fixtures in each toilet room.

Standards for lavatory heights were determined by Thomas (226) by using Bean's anthropological tables (55) as a basis, thus giving a range from eighteen inches for kindergarten to thirty-one inches for high-school students.

Toilets—There is a dearth of material on "standards," which term here refers to the number of various kinds of fixtures based on actual or functional studies. Dresslar (85:67) recommended one urinal for each thirty boys, "especially if teachers and principals will so order recesses that there will be no congestion." For primary grades he recommended one urinal for each twenty-five boys. As to toilets, one for each twenty girls in the lower grades and one for each twenty-five girls in high school. However, "these numbers are reductions from the writer's earlier estimates." Schmidt (207), on the other hand, increased the number of urinals on the basis of their ratio to closets, being 5:3 and 2:1 for high and elementary schools, respectively. These figures were based on func-

tional studies and peak loads, the latter being "corrected" on the basis of time studies. Very similar figures were given by Strayer and Engelhardt (220, 221), while Gerhard's (107:149) are very close to those of Schmidt. Alt (39:44) gave the number of fixtures as a function of total enrolment, based, however, on only a few school reports. Virtually all investigators called for various heights of closet bowls and seats, depending on the age of the pupils—as a rule "adult" sizes are used—and found that "it is positively insanitary and unjust to require little folks to use adult sizes" (85:67). Schmidt (207) also went into the physiological reasons for using proper heights of seats and recommended heights ranging from nine to fourteen inches. Thomas (226) gave very similar figures.

Interestingly enough, Thomas' study (226:118) referred mostly to urinals of the trough or suspended type; these types are either not mentioned at all or minimized by other writers—the floor type is considered modern, satisfactory, and standard for school use. Thomas (226:120) differed from Schmidt in the number of fixtures recommended; he used a sliding scale based on consensus of opinion and empirical data. Ireland (140) made a study of sanitation which is, in a measure, an extension of Thomas'.

Consensus of opinion favors toilet rooms to be located on classroom floors where "sunlight during the day is essential." Dresslar (85) emphasized good lighting and ventilation as well as Alt (39), who denied that these are obtainable in basement locations. All authors stress the need for good ventilation, but all are by no means in agreement as to specific methods. Both positive pressure and exhaust methods are in vogue.

Drinking fountains—Drinking fountains of a "sanitary" type are recommended by all writers. Thomas (226:82) favored the stream type and showed "that a larger portion of the fountains (other than stream) were infected with streptococci, which it is reasonable to assume came from the mouths of consumers." Interestingly enough, he stated that "according to the criterion used in this study it cannot be said that the fountain is superior to the individual drinking cup. If reasonable provisions can be made to assure an adequate supply of cups at all times, probably that method is to be preferred." No other mention of this fact was to be found except that the individual paper cup is mentioned from time to time as a substitute for the drinking fountain.

As to the number of fountains, there is not much dissension among investigators. The usual range is one fountain for from 75 to 100 pupils.

Swimming pools—The literature on this subject, at least that which is pertinent to school situations, is not extensive. Standards are discussed by the plumbers' trade journal (223) and the health department of California (70), the latter being quite specific from the health angle. Crane (83) and Kocher and Davison (149) gave construction data, while Mackey (163) contrasted the modern with the old. Purification was treated very fully in a series of articles by Hartman (116) and by the Indiana

State Board of Health (194). Interesting methods of underwater lighting of pools were discussed by Scherer (205) and Beggs (57).

Lighting

Natural.—The matter of lighting schoolrooms and its efficiency has been treated first from the angle of the hygienist and the ophthalmologist, and has been referred to in the older medical literature. One of the specific mentions of the relation of school planning to eye hygiene was made in Cohen's book on *Die Hygiene des Auges*, where reference was made to the importance of fenestration, though no particular recommendations were evident. Posey (187) treated the subject in a similar way but recommended unilateral lighting with a window area of one-fifth of the floor area and a "maximum hygienic value of 2½ foot candles." Merrill and Oaks (168) gave a good treatise on vision and recommended good lighting. Shawan (215), in his paper on conservation of vision, called attention to the strategic position of desks and windows but made no recommendation as to unilateral lighting, "due to study which shows no real trends." Jackson (143:314), in a similar study, favored unilateral lighting but permitted some lighting from the rear, and limited the width of classrooms. "Ideal is diffuse sky light," a statement which is not subscribed to in the literature except for exceptional cases, i.e., art rooms. "Excellent illumination can be secured . . . if only the impression of having light come from above is properly applied." He also advocated placing of windows six to seven feet above the floor and close to ceiling—on both sides of a room. Challman (76), Berkowitz (61), and others were all committed to unilateral lighting. A study by Ives (142) showed that out of thirty-nine states having regulations governing window lighting, thirty-one specified unilateral window arrangement, and fourteen also permitted some lighting from the rear. A study in the *London Times* (71) called attention to the physiological effects of good lighting (and heating and ventilation).

The amount of fenestration is usually defined as a function of the classroom floor area. It varies from one-seventh to one-fourth of the floor area. Ives (142) reported a preponderance of opinion in favor of a ratio of 1:5. Martin (166) argued for a ratio of 1:4 to 1:5, but called attention to the architectural difficulties in providing this large amount of window area. Scherer (204) argued for adequate lighting on physiological grounds but was satisfied with a ratio of 1:6 due to experience with lighting codes. M. E. Smith (216) gave an appraisal and checklist for lighting.

The effect of window placement and mullion widths was studied by Bishop (64) and he concluded that wide mullions influenced the amount of light materially, reducing it to 65 percent of normal, in front of a mullion, but in no case did the illumination fall below an acceptable minimum. On the other hand, Hamon and Taylor (111:44) stated, "This study (on horizontal window spacing) forces the writers to the conclusion

that we can secure just as good distribution of light by abandoning the "standard" battery arrangement of windows" and "that the distribution factor is in harmony with flexibility." Bishop used a standard classroom while Hamon and Taylor used a one-eighth scale model for experimental purposes. In a like vein Martin (166) called attention to obstructing piers and mullions, but felt that there were no real data available in this respect. Hopkinson (130) showed that window spacing is not a serious matter. Virtually all writers called attention to the effectiveness of a large "sky angle" and the positive effectiveness of the upper half of the windows; Hopkinson made special mention of it, while Jackson (143) called for shades on the lower sash rather than the upper as a means of light regulation.

Beal and Clark (229) made a monumental study of the influence of natural illumination in schoolrooms; their conclusions were quite technical, but showed large illumination variations on pupils' desks. Dresslar and Southerland (86:10-11) made a study of classroom orientation, using a one-twelfth scale model. They found on the basis of "interference with direct sunlight on desk tops," the orientations in the order of least interference are: NE, W, E, SW, SE, S. But the writers stated that in a great measure a room needs to be flooded with sunshine "to meet the demands of safe sanitation." Thus, "without going into further detail, we are completely justified in concluding . . . other things being equal, the order of preference of orientation is W, E, SW, SE, S."

The effect of the color of the decorations as well as glare are stressed a good deal; Powell and Bell (189), Berkowitz (61), and in particular Harrison and Anderson (112) called attention to this feature and the latter writers gave the reflection coefficients of thirty-two colors. Pennsylvania (181) and Wisconsin (242) publish "approved" color charts which have been scientifically tested. The School Lighting Code (137) also gave much data on this point, while Gamble's study (105) contributed to this phase of the subject.

The standards of the intensity of illumination in terms of foot candles have been investigated for years. Horstmann and Tousley (131) gave schoolroom standards as two- to three-foot candles. Luckiesh (160) gave similar figures and the whole matter was crystallized through the publication of the School Lighting Code of the Illuminating Engineering Society (195). This was adopted by Wisconsin as a part of the state's lighting code (243) and used by Pennsylvania as well. In 1924 the code was revised as sponsored by the Illuminating Engineering Society and the American Institute of Architects (137). Its final form was approved in 1932 (139). The code raised the illumination factors materially and required five-foot candles as a minimum for classrooms and recommended ten-foot candles. The code was generally accepted and was published by the United States Department of Labor (138). The Eyesight Conservation Council of America (42) also adopted this code as fundamental and published some practical ideas in connection therewith.

Freeman (102:350) reported a study in 1919 on the effect of light intensities on legibility and the speed of reading. Apparently diminishing returns are set up around three-foot candles for speed and two-foot candles for legibility. "As far as they go they indicate that the standards of the Illuminating Engineering Society are higher than necessary in the case of older children and adults." Scherer (204) also recommended a downward revision on the basis of greater experience with the 1918 code. Like Freeman, Albert (37) called attention to the relation of light and scholarship.

The National Society for the Prevention of Blindness (245) has published a report of a joint committee on health problems in education which gives a good summary of the problems of health, vision, and lighting. One of the recommendations made in connection with throwing the responsibility of health onto the school is as follows: "The school should provide a proper environment to promote eye health, such as adequate natural and artificial light, approved shades, light colored walls and ceiling, etc." (245:53). A report by Henderson and Lowell (119) gave up-to-date ideas on this subject.

Artificial—The development of artificial lighting of school buildings has kept pace with that of natural lighting and has been fostered by private and commercial interests as well as by national societies on the basis of scientific data provided by the physiologists, medical profession, and scientists. The Illuminating Engineering Society has contributed much pertinent material.

Knight and Jackson (148) carried on a statistical study of types of school lighting, showing the importance of distribution, avoidance of glare, etc.; indirect lighting was given a high rating. Ferree (98) discussed the effect of different systems on the eye, while Spaulding and Palmer (218) went into the matter of the efficiency of various kinds of lighting fixtures. The School Lighting Code (137) utilized most of its material in the direction of artificial lighting and gave quite specific and practical data in connection with determining the size and distribution of fixtures. Luckiesh (160) and others (92) treated the topic similarly. The National Lamp Works (174) showed the importance of good artificial lighting based on physiological considerations. In opposition (in part, at least) to Freeman (102), this booklet showed that a higher degree of illumination than usually found was beneficial as regards "perception, discrimination, fatigue, etc." A series of curves illustrated the claims made. The National Lamp Works (173) has compiled an excellent glossary of illuminating terms. A similar one will be found in the transactions of the Illuminating Engineering Society (136).

Pilkey (185:41) called attention to the importance of scientific data as a basis for providing artificial lighting in schoolrooms. "Artificial lighting is not a matter of hanging bare incandescent lamps haphazardly about the room." The writer recommended twelve- to six-foot candles of illumina-

tion for classrooms. Powell (188:43) argued for adequate illumination and color decorations in keeping with the principles of the illuminating art. ". . . It has been proved beyond doubt that adequate illumination does affect acuity . . . and that . . . it is quite possible to secure illumination which is adequate, proper and at the same time artistic." Bennett and Maloney (59) gave some convincing illustrations on the effect of color, etc. on the intensity of illumination. Sturrock (222) made a plea for higher intensity of illumination and showed the beneficial effects of raising the intensity from three- to twelve-foot candles and cited at length Atwater's paper (47) on a like matter. The special committee of the Society of Illuminating Engineers (46) recommended five-foot candles and special precautions against glare. They also recommended special lighting for libraries, as did MacDonald (162). Atwater's treatise (48) on windowless schools gave a new and modern slant on this subject.

With the newer developments of the older selenium cells, the photoelectric cell or eye has come into its application to schoolroom lighting and control. Advocated by the electrical interests and taken up by schoolmen it is gaining favor. Frostic (103:50) reported an installation in Wyandotte, Michigan, such that two control rooms and one corridor master cell control the switching of the artificial lighting units, thus keeping the light variation within very close limits as compared with manual control. "Contrary to general opinion, with equal window area and floor-window ratios there is less demand for artificial lighting on the north exposure, in northern latitudes at least, than for southern exposures, due to better diffusion of light."

Atwater (47:296) called attention to a similar situation in Tuscumbia, Alabama, where a control experiment in automatic light control (photoelectric cell) has been in progress for three years. "The children in room I (automatic control) were much more alert, cheerful, and attentive, while those in room II (manual control) seemed restless and sleepy on dark days and were harder to teach."

Of late years the therapeutic effects of natural lighting have received considerable attention and there seems to be a difference of opinion regarding the use and effectiveness of special glass transmitting ultra-violet rays. Keller (147) gave a good deal of credit to ultra-violet ray transmitting glass in promoting nutrition and general health. W. H. Eddy (91) reported similarly that the glass transmitted sufficient rays to prevent rickets, provided the rays were direct and exposure lengthy. Oday and Porter (180) favored ultra-violet sources of light for general illumination. The *American School Board Journal* gave a résumé (93) of a number of school experiments to show a gain in health and a better scholarship rating for pupils exposed to ultra-violet glass. On the other hand an article (213) in *Survey* showed that there was no advantage as regarded general health scores of children exposed to ultra-violet light.

Stage lighting was given extensive treatment by Fuchs (104), while Carey (72) referred specifically to schools. Selden and Sellman (214)

also gave pertinent material to the subject in connection with scenery production. Permaflex has issued a bulletin giving practical ideas on the use of reflectors for stage work (49).

Recommendations

It will appear from the foregoing summaries that many problems need solution. Among these are:

1. What percent of outside (primary) air is *really necessary* under ordinary conditions?
2. What is the number of air changes that are *needed* in a schoolroom and what air motion is essential?
3. What are the characteristics of window ventilation, and what are their relations to those of a mechanical system?
4. Exact data on the performance of various systems of ventilation under control conditions and in relation to each other.
5. The development of generally accepted criteria to be used in these investigations.
6. Accurate data as to the effectiveness of ozone in connection with air conditioning.
7. The effect, physiological and psychological, of recirculated air in varying proportions.
8. More empirical data on the necessary number of toilet fixtures under differing types of school organization.
9. Control experiments with acceptable criteria for determining the required intensity of schoolroom artificial lighting, possibly based on physiological factors.
10. Empirical data of the effect of different horizontal window arrangements in actual practice.
11. A record, possibly automatic, of the variation of daylight intensities for continuous periods in classrooms, as a basis for determining window areas for different sections of the country. (A "prediction" formula may be developed in this connection.) This would be an extension of Beal's study (229).
12. Accurate data on the effectiveness (and train of consequences, if any) of unilateral versus bilateral (two sides or one side and rear) schoolroom lighting.

CHAPTER III

Equipment, Apparatus, and Supplies

THIS CHAPTER REPORTS certain trends in the field of school equipment and supplies as revealed by professional writings published between July, 1932 and January, 1935.

The *Review of Educational Research* for December, 1932 defined school equipment and supplies as those commodities which contribute directly or indirectly to the work of instruction. Although supplies and equipment are sometimes confused, they may be differentiated by the fact that supplies are consumed by use during the year, whereas equipment is expected to be used over and over again year after year. It is commonly accepted that satisfactory supplies and equipment contribute significantly to the successful operation and maintenance of a school at modern standards.

The 1931 budgets of many school districts were the largest in their history. Since then, however, practically every school system has found it necessary to reduce expenditures. Even schools that felt they were operating on a minimum expenditure per pupil have been forced to find still stricter means of economy. During the past three years, the predominating note expressed in professional writings about equipment and supplies has been economy in the use and conservation of materials, and the application of efficient business principles to their selection and purchase.

Undoubtedly, there is a wide variety of policies and practices followed by boards of education throughout the country in the expenditure of appropriations for educational equipment and supplies. If a change to a better policy will permit the purchase of the same quality of materials at a lower cost, desirable economies can be effected. Basic policies to accomplish this have been outlined by Cline (267), Collins (269), Frostic (281), Hibbert (302), Nash (323), O'Dell (333), Richardson (342), Shreve (345), Ullrich (357), and others (304). These writers have advocated definite standards and specifications to meet the needs of the changing trends in administrative practices. Adoption of standards and specifications for the purchase of equipment and supplies is a means of measuring the proposals made by various bidders. Such standards are considered fair to the bidders. They tend to eliminate inferior products that so often prove costly in the end, and they are a distinct help and service to boards of education.

Since the cheapest products often prove to be the most expensive, particular care should be taken at times when appropriations are low, in selecting the best quality available for the amount of money to be spent. Selecting the bidder and measuring the quality of the products submitted to the school were discussed by Bennett (253), Bruce (260), Cheney (265),

Cocking (268), Jones (309), McClinton (316), Miller (320), and others (261, 319, 325). Reducing the cost of school equipment and supplies by quantity and cooperative buying was treated by Lex (311), Morris (321), Young (362), and others (344). In communities where the local governments are so constituted as to permit it, a central purchasing bureau may be the means of reducing costs by cooperative and quantity purchases.

Methods of control of equipment and supplies, particularly regarding storing, distributing, maintaining, and accounting for school materials, were discussed by Bible (256), Chambers (263), Clark (266), Frostic (284), and others (338). Even the best organized school systems have openings for minor wastes, for which these authors suggested remedies.

There is a large number of specific items in the field of school equipment and supplies which are of special rather than general interest.

The effect of the National Industrial Recovery Act on school supplies and equipment was described by Brodinsky (258).

Checklists, specifications, and inventories were rather widely discussed. Eleven particularly instructive references were found (254, 255, 264, 301, 306, 339, 343, 348, 353, 354, 361). Definite specifications and the use of checklists were found to be a distinct economy in the selection and purchase of school equipment.

There were many reports on new room layouts and equipment lists for special rooms. Shop room layouts predominated. Eleven studies well worth consultation were made by Brandt (257), Brodshaug (259), Calhoun (262), Coté (270), Hamon and Standish (288), Patterson (336), Resides (341), Stahl (350), Taylor (353), and Wagner (359).

The popularity of visual education and sound amplifying apparatus in the schools appears to be increasing. Seven references on these subjects were noted (272, 273, 298, 299, 310, 347, 356).

References to safety and health devices were frequent, such as those by Armstrong (251), Frostic (282), Hart (289, 290, 291, 293, 295, 296), Homan (303), Nelson (326), and others (328). Lockers, fire alarms, cleaning devices, laundries, adjustable seats, and heat control instruments were discussed in relation to health and safety.

The proper lighting, the control of light, and the conservation of sight were discussed by Ferree and Rand (275), Frostic (279, 280), Sturrock (351), and others (327, 330).

Innovations in equipment including benches, blackboards, chairs, and office machines were reviewed by Hart (292, 297, 300), Hughes (305), and others (252, 274, 307, 308, 314, 318).

Scattered references were reported on many items for the improvement of the schools: dishwashing machines and equipment, cleaning compounds and soap dispensers, painting and decorating, sound deadening materials, locks and lockers, blackboards, musical instruments, floodlights, museum material, school buses, sanitation supplies, playground equipment, and the like. The bibliography to this chapter (Nos. 251-362) gives 112 references to school equipment and supplies published since July, 1932.

CHAPTER IV

School Playgrounds: Their Surfacing, Administration, Use, and Care

THE ACTUAL BEGINNING of the modern organized playground in America is credited by Pangburn (376) to Boston, whose sand gardens were opened in 1885 under the supervision of matrons. In 1891 playgrounds provided only about one acre of space to every 1,000 to 1,500 children. In the early years of the movement, private, voluntary effort secured and maintained playgrounds, through tag days, bazaars, and public subscriptions. By 1929, however, 84 percent of the year's expenditure of over 33½ million dollars for public recreation in the United States was tax money.

Curtis (367) in 1921 attributed the new emphasis on organized games and athletics to the influence of the war. He stated that since 1916, 28 states had passed laws putting organized games and athletics into the program of the public schools. By 1930, according to Ready (378), 37 states had enacted such laws.

Nash (370) noted four distinct stages in the development of the playground movement as follows:

1. The charity stage prior to 1900 when the money for the support of playgrounds was raised by private means.
2. The park stage which may be thought of roughly as the decade between 1900 and 1910. During this stage tax support came to the aid of the playground movement and the administration naturally fell to the city park departments because they had the land. Because the park did not meet the real needs, the Playground and Recreation Association of America was organized in 1906 and paved the way for the third stage between 1910 and 1920.
3. The trend during this period was toward separate recreation commissions and demand for trained supervisors. Following the World War there was a flood of legislation relative to physical education. "This was largely the basis for the fourth stage, which with the help of other social movements bids fair to bring to America the solution of this problem."
4. The school stage. With the new interpretation that is being placed on physical education, the school is able to assume the responsibility for the full out-of-school playtime of the children. With the school already in contact with all the children of the community, it is the only institution that can guarantee full play opportunities to all children.

Thus recreation and physical education with the necessary grounds and equipment have become important functions of the public schools, with the probability that boards of education will be increasingly given the responsibility for all public recreation programs.

Organization and Administration

Rogers (379), in 1924, reported a study which he had made of the organization and administration of recreation in the cities of the country. At that time, 52 of the 56 cities of over 100,000 population replying to his questionnaire stated that they had playgrounds other than those connected with the school. Forty-six cities reported municipal control of these playgrounds; 6, control by the board of education; and 2 cities, joint management by the two agencies. The administration of school playgrounds in 25 cities was under the exclusive supervision of the schools, but in 24 cities they were under the control of some other municipal agency after school hours or in the summer. Forty-seven cities were providing playgrounds for all new buildings. "Of the 39 cities venturing an opinion as to administrative control, 29 believed that the schoolboard should supervise all playgrounds of the city, 11 favored municipal supervision, and 3 thought there should be dual management—of the school playgrounds by the board of education and of the municipal grounds by municipal authorities."

Nash (370) published data showing that in 1925 the administration of municipal recreation systems in 214 cities was as follows:

Independent recreation commission	93
Schoolboards	40
Recreation bureau in park departments	28
Joint departments or commissions	21
Other city departments	8
More than one department or divided responsibility	24

The same writer (369) prepared a comprehensive discussion of the administration and supervision of physical education.

Smith (381) reported a questionnaire study of playground supervision in Arizona elementary schools. He found a large majority of the schools were providing play programs with adequate supervision. Weiland's study (382) of 134 Nebraska schools found the play program in most of the schools to consist of fifteen-minute recess periods in both morning and afternoon which were supervised by the teachers. Rowe (380) described a plan worked out in Cleveland for the selection and rating of the employed personnel of summer playgrounds by means of score cards and rating sheets.

The effectiveness of playground supervision in Los Angeles in preventing accidents is reported in the following words:

City children are less likely to be injured while playing on a supervised playground than anywhere else. . . . In the year 1932-33 in the city of Los Angeles there were only 69 playground accidents reported, although the total attendance exceeded ten million. The principal contributing factors to these accidents were tripping, falling and collision, loss of grip on play apparatus, playing in restricted areas, unauthorized climbing, and improper use of apparatus. Careless throwing or swinging of bats, sticks, and mallets also resulted in a number of accidents (365).

Size and Location of Playgrounds

The Playground and Recreation Association of America (377) made studies in a number of large cities which showed that nearly one-half of the children attending playgrounds live within a quarter of a mile of the areas studied and that comparatively few children walk more than a half mile in order to reach a playground. They concluded that

. . . danger from street traffic is perhaps the most important factor in determining the distance children will walk to attend a playground, and as a rule the effective radius of playgrounds in smaller communities is greater than in large cities. Experience has shown that the maximum effective radius of a children's playground is one-half mile or less and it is generally agreed that a playground should be provided within one-half mile of every home. . . . Many cities have adopted the policy of providing children's playgrounds either on their elementary-school sites or adjacent to them.

Nash (369) analyzed the space needs for both neighborhood and district playgrounds. He concluded that to accommodate a maximum of 288 players, a neighborhood playground should have 4.4 acres, and a district playground should have 7.1 acres for 242 players. This difference in size is due to the different programs recommended for neighborhood and district playgrounds.

Ready (378) found that 8 states have laws requiring that certain areas be provided for school playgrounds, while state boards of education in 20 states have made rules and regulations requiring certain areas for school sites. Areas required by law were found to vary from one to six acres, while rules and regulations of state boards of education vary for elementary schools from one to six acres and in junior and senior high schools from two to ten acres. The same study also called attention to the gradual development of standards in determining necessary play space. The Playground and Recreation Association of America (377) stated that "the minimum size for a neighborhood playfield should be ten acres . . . a twenty-acre tract is preferable."

The National Recreation Association (373) made one of the most thorough studies of space requirements for playgrounds. Table 4 (p. 367) gives a comparison of requirements for playgrounds to accommodate approximately 600, 300, and 1,000 children aged five to fifteen years.

Playground Equipment

A committee (372) of seventeen recreation executives prepared the following as minimum standards for playground equipment:

Children under six years: Chair swings,—set of six; sand box (in two sections); small slide; simple low climbing device.

Children six-twelve years and older: Swings—frame 12 feet (set of six); slide—8 feet high, 16 feet long; horizontal ladder; traveling rings or giant stride; balance beam; see-saws (set of three or four).

Optional: Horizontal bar; giant stride or traveling rings (whichever is not provided above); low climbing device.

According to the California physical education manual (375), elementary-school playgrounds should be provided with a safety climbing tree, safety platform slide, graduated horizontal bars, parazontal bars, two horizontal ladders, stationary travel rings, giant stride, junior jungle-gyms. Hungerford (368) published a description and plans of play apparatus made and used in the Preschool Laboratory of the Iowa Child Welfare Research Station. Nash (370), the National Recreation Association (372, 377), and a number of the state departments of education have published material concerning playground equipment.

TABLE 4.—PLAYGROUND STANDARDS OF THE NATIONAL RECREATION ASSOCIATION (373)

Standards	Standard	Limited	Large
Child population to be served.....	600	300	1,000
Apparatus area (square feet)	7,700	5,600	10,270
Child capacity of apparatus area.....	122	65	74
Average square feet per child served.....	63	86	74
Area for equipment (square feet)	21,300	13,000	30,900
Child capacity of this area.....	285	170	450
Average square feet per child served.....	75	76	69
Special areas for games and sports (square feet)	109,975	83,150	169,560
Child capacity of this area.....	156	118	250
Average square feet per child served.....	705	704	678
Total area of playground (square feet)	151,975	111,250	233,230
Total area of playground (acres)	3.49	2.55	5.35
Child capacity of total playground.....	563	353	859
Average square feet per child served.....	270	315	272
Child capacity per acre.....	161	138	160

Playground Surfaces

The problem of finding a means of surfacing playgrounds which will meet all requirements remains to be solved. Altenburg (363) who made a study of play facilities in 71 elementary schools in 71 cities concluded that "despite the great amount of studying that has been done on this problem, there does not seem to be any standard followed for surfacing play areas in the schools that were examined for this study . . . (and) it would seem that surfacing of playgrounds has been more or less haphazard." Condit (366) concluded that "no surfacing has yet been devised which is ideal or satisfactory for every ground." Different parts of play areas require different kinds of surfacing and different soils and physical conditions produce special problems. Butler (364) reported that a group at the National Recreation Congress agreed that on all children's playgrounds intensively used the year round, it is desirable that a part of the area should be surfaced with hard material, preferably of a bituminous nature and that this part should be located adjoining the building.

The Playground and Recreation Association of America (377) has given the following résumé of the methods used in various localities:

The surfacing which has proved successful in Detroit, and which is practically identical with that recommended by the New York State Board of Education for schoolyards and playgrounds, is prepared as follows: All grass, weeds, stones, humus material or other débris are removed and a fill of clean cinders is put in. The cinders, which should not exceed 2 inches in diameter, are spread to a depth of 3 inches, wet and rolled with a suitable roller until no waves appear in front of the roller. The finished grade of this course should parallel the finished grade of the finished course. This course ought to be wet before the second course is applied.

The second course consists of 3 inches of limestone screenings and dust spread evenly over the first course, rolled with a suitable roller, and wet between the rollings until a smooth compact surface is obtained.

The third course consists of calcium chloride spread evenly over the entire surface, about 1½ pounds per square yard. As a fourth course, ¼ inch of coarse, sharp sand is spread evenly over the entire surface.

The special committee on surfacing of playgrounds appointed in June, 1924, to make a study of the problem, presented the following suggestions for the consideration of the Chicago Board of Education:

1. The Committee condemns the use of cinders for surfacing either on playgrounds or school grounds used for play purposes.
2. Future playgrounds should be crowned to drain to the side, rather than the present method of draining to the center.
3. In the case of playgrounds now constructed in which cinders combine or compose the major portion, the cinders should either be removed or regraded to permit not less than a 4-inch coating of yellow clay to be properly rolled and surfaced with torpedo sand. The use of yellow clay with a sticky texture is preferred.
4. In the case of new playgrounds to be constructed, they should be excavated, if necessary, 14 inches and filled with at least 6 inches of cinders, properly rolled and 6 inches of yellow clay, properly rolled; surfaced with torpedo sand and drained to the side. The subgrade upon which the cinders rest should be parallel to the finished grade.
5. All grounds should be treated at least twice a year with a solution of calcium chloride, approximately ¼ gallon to the square yard (liquid form).

In response to a request made by a group of recreation authorities that a special study be made of the problems involved in surfacing recreation areas, the National Recreation Association (374) appointed a committee of eleven recreation executives to conduct such a study. The committee limited its inquiry to such areas as were devoted primarily to children's play and to specially surfaced courts used for tennis, handball, and similar games. An effort was made to collect information concerning the various kinds of materials used for surfacing such play areas, the methods of constructing and maintaining the surfaces, and the cost involved. The report of the committee contains detailed specifications for a great number of the most satisfactory surfaces.

Wiley, in the 1932 proceedings of the National Council on Schoolhouse Construction (371), reported on the experience in playground surfacing in Milwaukee. Between 1922 and 1931, 46 playgrounds were treated or reconstructed with penetration tar macadam of various types, and 23 were

treated with oil on sand, gravel, cinders, furnace slag, and other mixtures. None of these treatments was entirely satisfactory. He reported that one of the larger playground areas had been divided and equal sections treated with Kentucky rock asphalt, penetration tar macadam, emulsified asphalt, premixed tar with tar-seal coat, and premixed tar with asphalt-seal coat. From this experimental set-up it may be possible to make comparisons under identical conditions of these different kinds of playground surfacings.

CHAPTER V

Public School Plant Insurance

IN THE ISSUE FOR DECEMBER, 1932, of the *Review of Educational Research* dealing with school buildings, grounds, equipment, apparatus, and supplies, no data were presented on the problem of school plant insurance. However, since that review was prepared, boards of education, in their efforts to find means of reducing school costs without seriously affecting the school program, have given considerable attention to school plant insurance as one means. As a result of these efforts, a number of recent studies have been made in this area.

Since this problem is likewise a financial one, it was briefly presented under the general title of "Management of the School Plant" in the second cycle of the *Review* in the April, 1935, issue on finance and business administration. Because of the recent and current interest in the field of school plant insurance which, as stated above, has resulted in a number of investigations, it seems advisable to make a separate chapter in this number for such material as is available on the topic.

Present Status of School Plant Insurance Legislation

Melchior (393), in one of the pioneer investigations in the school plant insurance field in 1925, studied, among other things, the legal requirements pertaining to school insurance in each of the 48 states, Alaska, the District of Columbia, and Puerto Rico. He found that 12 had mandatory provisions for school plant insurance, 9 permissive provisions, and that 30 had no legal requirements. Werner (402), in 1935, made a similar study and found that the number of states and subdivisions with mandatory legal provisions for school plant insurance had increased from 12 to 16, those with permissive provisions had decreased from 9 to 8, and those with no legal requirements from 30 to 27. The trend, then, as evidenced by these two studies, made ten years apart, is toward mandatory requirements for school plant insurance. The states falling into each of these classifications, according to Werner, are as follows:

With mandatory provisions: Alabama, Arizona, California, Colorado, Delaware, Idaho, Maine, Montana, Nevada, New Mexico, New York, North Dakota, South Carolina, Texas, Vermont, and Wisconsin.

With permissive provisions: District of Columbia, Iowa, Kentucky, Michigan, New Hampshire, Pennsylvania, Mississippi, and Washington.

With no legal requirements: Alaska, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Kansas, Louisiana, Maryland, Massachusetts, Minnesota, Missouri, Nebraska, New Jersey, North Carolina, Ohio, Oklahoma, Oregon, Puerto Rico, Rhode Island, South Dakota, Tennessee, Utah, Virginia, West Virginia, and Wyoming.

State Plans for Self-Insurance

South Carolina in 1900 was the first state to set up a system of state insurance on public buildings by making provisions to write 10 percent of the fire insurance on buildings of the state institutions. This plan as it has developed was reviewed by Miller (394) in 1931 and brought down to 1934 by Holy (389). Its main provisions are:

1. All of the insurance—fire, lightning, and windstorm—on all the public buildings of the state, counties, and on public school buildings is now carried by the state. School buildings were first so insured in 1913.
2. The fund is under the control of a sinking fund committee made up of six ex-officio members, four of whom are executive and two legislative.
3. The rate charged at the beginning was essentially that of regular insurance companies with the profits resulting therefrom going into a permanent fund with the ultimate object of providing free insurance.
4. The state law provides that when this permanent fund reaches a million dollars, free insurance will be carried on all buildings in the fund for five years more, so long as the permanent fund does not fall below the limitation fixed by law.
5. This million dollar permanent fund was reached in 1926. Between that time and June 30, 1934, only one assessment, amounting to 75 percent of the regular annual premium, has been levied against the property carried on free policies by virtue of the five-year provision.
6. On June 30, 1934, out of a total of \$41,204,047 of property insured by the state, \$34,581,795 or 84 percent of the total was carried under these free policies.

The general provisions of the Wisconsin plan, created in 1903, and amended in 1911 and 1913 to include (but not on a mandatory basis) public school buildings, and those for North Dakota, where such a plan has been in effect since 1919, were reviewed by Holy (389). In the former state the rates charged for school buildings are 49 percent of those charged by regular stock companies doing business in the state, and in the latter the rates are approximately 75 percent of those charged by fire insurance companies operating in the state.

The general provisions of the state plans in operation in Alabama, Florida, and Michigan were given by Sensing (397). He also pointed out that Tennessee in 1905 created a fund of \$75,000 to protect a few state-owned buildings. This fund, however, which in 1931 amounted to \$145,413, applies to only a small number of state-owned buildings. He further pointed out that Louisiana has a law which permits the state to finance the insurance of state college buildings, but this law has not been operative.

City Plans for Self-Insurance

A comprehensive study made in 1932 by a special committee of the National Association of Public School Business Officials (395) deals in one section with self-insurance as practiced in city school districts. This study reported that "at least" 49 city school districts had at that time self-insurance plans (395: 114).

The result of the survey covering the self-insurance phase of this report, reveals a total of 49 cities, representing a total population of 22,916,937; 4,556 buildings with

a total valuation of \$1,274,729,897.30. The losses reported total \$1,415,352.99. The ratio of losses to total valuation being eleven thousandths of one per cent., which unquestionably indicates that the self-insurance plan for large cities with a large number of risks well scattered is absolutely sound in theory, and has proved itself in practice.

Of each dollar paid to insurance companies for premiums only approximately one-half is designed for payments of losses, the purpose of the other half being that of overhead and expense. It is most certain that school districts can conduct their own insurance for but a small fraction of fifty per cent. so that even if the school losses should run as heavy as the average for all properties (which is far from the case), there would still be a very material saving under this fifty per cent. underwriting expense item.

Among this group of 49 cities are Boston, Chicago, Cleveland, Cincinnati, Detroit, Kansas City, Milwaukee, New York, Philadelphia, San Francisco, St. Louis, and Washington, D. C.

Because the Cincinnati plan, which began in 1912, was among the first of the self-insurance plans, it is briefly reviewed here. Quoted from Holy (389) is the following relating to this plan:

For each year from 1912 to 1924 inclusive, the Cincinnati Board of Education transferred \$25,000 from the general fund to the replacement fund, which with earnings amounted to \$361,000 in 1924. In 1925, the Board fixed the maximum of the fund at \$350,000, so the difference, together with later income, was transferred back to the general fund. In 1928 the Board decided that the funds should be allowed to increase to \$500,000. On October 19, 1934, it amounted to \$450,568.

A study of the expenditures made from this fund for losses to school property show that none were made between 1912 and 1928. Upon investigation it was found that no school fire occurred in Cincinnati during that period. If all the property losses paid from this fund are distributed over the 22 years during which the plan has been in operation, they amount to an average annual loss of \$879. On the basis of insurance premiums paid in five other large Ohio cities, it is estimated that this plan of self-insurance has saved the Cincinnati school district, after all losses have been deducted, \$204,000. No appropriation has been made to this fund since 1924.

Drake (385), in reporting for Columbus, Ohio, where there is neither school building insurance nor a replacement fund for protection, found that over a 35-year period there had been only four small school fires, representing a total loss of \$13,000. On the basis of the 1927 valuations of school property in the district, he estimated that an 80 percent fire insurance coverage would cost the Board of Education approximately \$30,000 a year.

Comparison of School Plant Insurance Premiums and Losses

Keith and Taggart (390) were authorized by the General Assembly of Pennsylvania to make a study of school plant insurance in the state and "present their conclusions thereon to the session of the General Assembly to be held in the year 1929." Their study covered the five-year period 1922 to 1927, and included about 25 percent of the school districts of the state, exclusive of Philadelphia and Pittsburgh. They found that the total amount of premiums paid in these districts during the five-year period was \$1,071,092, and that the losses amounted to \$220,976, or slightly

more than 20 percent of the premiums paid. During the same period the loss ratio in Pittsburgh was 21.7 percent.

Werner (401) gave figures on the loss ratio in four states. (See Table 5.) Pennsylvania, which is included in the report, is not given here because similar figures appear above.

TABLE 5.—SCHOOL PLANT INSURANCE LOSSES IN FOUR STATES, AFTER WERNER (401)

State	Years	Total premiums	Total losses	Percent losses are of premiums
Maryland	1926, 1928, 1930, and 1931	\$84,613 ^a	\$14,586 ^a	17.2
Missouri	1927-1931	2,400,000	936,000	39.0
Texas	1931	774,629	372,501	49.2
Virginia	1925-1930	189,687 ^a	145,925 ^a	77.0

^a Average annual figures.

Holy (388), in a series of studies covering all the school districts of Ohio for a four-year period, found ratios as given in Table 6.

TABLE 6.—SCHOOL PLANT INSURANCE LOSSES IN OHIO, 1930-33, AFTER HOLY (388)

Item	1930	1931	1932	1933
Fire insurance premiums paid	\$514,576	\$465,077	\$372,369	\$403,152
Fire losses	14,444 ^a	47,386 ^a	14,573 ^b	39,562 ^b
Percent loss is of premium	2.8	10.2	3.9	9.8

^a For these two years, the losses are those from fire reported to the state fire marshal.

^b For these two years, the figures represent actual amounts received "from insurance companies for losses to school property."

He also prepared a table showing the ratio which premiums paid for school property insurance in Ohio was of the total net premiums received by fire insurance companies for Ohio business. These percents for each of the four years were as follows:

1930	1.41 percent
1931	1.45 "
1932	1.39 "
1933	1.66 "

These low ratios of losses to premiums paid, which are based on actual reports for each school district in Ohio, as compared with the states given previously, are no doubt partly due to the large proportion of fireproof buildings in Ohio. In an unpublished survey made by the Ohio State Planning Board in 1934 it was found that 8 percent of the public school enrolment in the state was housed in frame buildings, 32 percent in build-

ings having "exterior of brick, stone, or reinforced concrete walls with floors and other interior construction wholly or in part of wood," and the remaining 60 percent in fireproof buildings.

In the study made by the National Association of Public School Business Officials (395), to which reference has already been made, it is found that the ratio of fire losses to premium payments on fire-resistive buildings valued at nearly \$500,000,000 was 8.76 percent, while on buildings of ordinary construction, valued at nearly \$400,000,000, the ratio was 41.4 percent.

The director of research for the Arizona State Department of Public Instruction (383), in a study covering the state of Arizona for the period July 1, 1932, to June 30, 1934, found the premiums paid and losses collected for buildings classified as to the type of construction shown in Table 7.

TABLE 7.—SCHOOL PLANT INSURANCE LOSSES IN ARIZONA, 1932-34 (383)

Item	Fire resistive	Ordinary construction	All types (blanket coverage)	Total
Premiums paid.....	\$18,544	\$9,397	\$34,946	\$62,887
Losses collected.....	331	16,467	21,600	38,398
Percent which losses were of premiums	1.8	175	62	61

A number of other studies showing the relation of premiums paid to losses collected have been made for individual districts, but they likewise show a relatively low ratio.

Reducing Commercial Insurance Costs

H. A. Smith (399), in a careful study entitled *Economy in Public School Fire Insurance*, stated that his main purpose in making the study was "to discover economical and, at the same time, safe methods of insuring public school buildings against fire." His findings were based largely on a questionnaire asking for the valuation of school property and the amount of fire losses suffered in all cities of more than 30,000 population in the United States. His conclusions and possible economies based on those data are listed under the following headings:

1. Economies through writing all insurance policies for a five-year term
2. Economies through the installation of automatic sprinkler systems in wood-working shops
3. Economies through having a careful appraisal of the school property and placing all insurance written under the co-insurance clause for 80 percent of the insurable value of the property
4. Economies through making minor inexpensive changes in the construction of the building, thus causing a reduction of rates
5. Economies through removing certain charges added to the rates because of faults of management
6. Economies through the installation of electric power in place of steam boilers.

He also found that the loss per \$100 valuation in 65 cities was nine times as great on buildings of ordinary construction as on buildings of fire-resistive construction.

Viles (400), in an unpublished dissertation, reported a study of the effect of fire hazards on insurance costs in 516 grade- and high-school buildings selected at random in Missouri. These buildings were classified according to type of construction, and the actual or published insurance rates compared with the base rates for each group. The latter is determined by the class of the town, type of buildings, and fire-fighting facilities. To this base rate are added certain penalties resulting from such causes as structural defects and type of occupancy, to make up the actual or published rates. His findings are contained in Table 8.

TABLE 8.—COMPARATIVE INSURANCE RATES FOR 516 SCHOOL BUILDINGS IN MISSOURI, AFTER VILES (400)

Class of building	Number of buildings of each class	Average base rate per \$100	Average published rate per \$100
High school, fire-resistive.....	20	.273	.558
Grade school, fire-resistive.....	20	.224	.374
High school, brick or stone with wood interior.....	153	.567	1.026
Grade school, brick or stone with wood interior.....	289	.569	.845
High school and grade, frame.....	25	1.148	1.351

The summary of his study is quoted here:

On these buildings about one-third of the average published rate is made up of penalties levied because of the fire hazards found in the building. These penalties may be divided roughly into four classes: Structural, occupancy, exposure, and after-charges.

The structural penalties are levied because of the presence of fire hazards created by the construction of the building. The heating plant, ventilating system, shop units, and the home economics department are common sources of these penalties.

The aftercharge penalties are often levied because of poor housekeeping and poor maintenance methods. Defective wiring, stoves with poor protection, the lack of pilot light, insufficient stovepipe protection, broken plaster, and rubbish in the building may draw heavy penalties.

The large number of these penalties may be eliminated without much cost by removing the fire hazard for which they are levied. Some of the penalties can be avoided by proper attention to construction details when the building is erected.

Linn (391) reported that in a single 34-year old building, an appraisal which cost \$450 resulted in a net annual saving of \$1,154 in insurance. He also reported that in the city of Muskegon, Michigan, the Board of Education, by means of reappraisal of the school buildings and contents, reduced the amount of insurance necessary for adequate protection so that an annual saving on premiums of \$3,000 was effected.

Beach (384), in a study of school plant insurance at Oyster Bay, Long Island, found that with proper appraisals, elimination of certain fire

hazards, and changing the policies all to five-year terms, the annual premiums were reduced by approximately 30 percent.

On the basis of a study of 150 school buildings, Holmes (387) found an average error of slightly more than 20 percent in the insurance underwriting.

Miscellaneous

There are a few references which do not fit into the other classifications, which are grouped here. Little (392) reported a contract agreement between three school trustees associations and three mutual fire insurance companies operating in three provinces in western Canada. Two conditions of the first agreement, made in 1930, were:

1. That the school rates be reduced 20 percent
2. "That any surplus of premium income available, after payment of fire losses, necessary operating expenses, and an agreed percentage for company reserves, be set aside as property of the schools insured under the plan to be used to reduce insurance premiums when policies are renewed."

The plan, which now includes about 5,000 schools, has resulted in a series of rate reductions until in 1935 when the rate on rural schools, formerly \$1.50 per hundred of insurance, was reduced to \$1.00 per hundred. Losses have also been substantially reduced since the agreement became effective. This agreement came as a compromise plan after it was found by the trustees that they did not have legal authority to organize a plan of self-insurance.

A number of texts on school administration deal more or less extensively with school plant insurance. Among these are Engelhardt and Engelhardt (386), Reeder (396), H. P. Smith (398), and Womrath (403). These are not reviewed here because such materials of research character as are reported in these are already in accessible form. Also, there are a number of minor studies in which the findings merely reaffirm those reported here. For that reason they have not been included.

At least two states, Idaho and Texas, voted in 1935 on bills setting up a state plan for school plant insurance. In Idaho, the bill passed the House by a vote of forty to eleven, but failed to get to the Senate, along with several hundred other bills. In Texas the bill was favorably voted out of the House Insurance Committee but failed to reach the floor of the House, largely, it is reported, because of its highly controversial nature. In 1933, a joint legislative committee in Ohio prepared a bill setting up a plan of state insurance for school property. However, this bill, along with a number of other measures designed to reduce school costs, was not enacted into law. In 1935, another joint Ohio legislative committee appointed a sub-committee to study this problem again. At the time this is written, this committee has not yet reported.

Conclusions

An analysis of the materials in this field point to the following conclusions:

1. Within the last five years, interest in the problem of school plant insurance has greatly increased due, no doubt, to the efforts of school officials to decrease school costs with least detriment to the educational program.

2. Practically all studies on the comparison of school insurance premiums and losses to school property have shown losses relatively low as compared with premiums paid. In Ohio, where studies of this comparison by individual districts for a four-year period have been made, it was shown that losses in relation to premiums were 2.8 percent in 1930, 10.2 percent in 1931, 3.9 percent in 1932, and 9.8 percent in 1933.

3. Chiefly because of the findings pointed out under two, the trend in the schools throughout the country seems definitely in these directions:

- a. Co-insurance, in which the loss hazards are shared by the owners
- b. General reductions in the amount of commercial insurance carried, particularly on fire-resistive buildings
- c. Appraisal of property to determine the actual insurance necessary for adequate protection
- d. Plans of self-insurance, either by states or individual city school districts
- e. Elimination of all insurance protection.

CHAPTER VI

Operation and Care of the School Plant

THE DECEMBER, 1932 ISSUE of the *Review of Educational Research*, which was devoted to the subject of school buildings, included only brief mention of the operation and care of the school plant. This chapter will therefore include some studies made prior to the date of that issue. Under the subject of operation will also be included studies of the personnel engaged in operating the school plant.

Reeves (429), who has made one of the most extensive studies of janitor service, emphasized the importance of the school janitor and his service in the following connections:

1. School health and sanitation
2. The influence of physical conditions upon the comfort and learning attitude of the child
3. The influence upon pupils of order and cleanliness of buildings in the maintenance of discipline, the formation of character, and the acquirement of habits of cleanliness
4. The wider use of the school building and equipment by the school and the community
5. The care of the valuable public property in the form of grounds, buildings, and equipment.

Status of the School Janitor

Garber (416) made a questionnaire study of the school janitors in 1,109 cities. He found that only 7 percent of the cities used the civil service method in the selection and appointment of school janitors, and only 73 of the cities required applicants to pass a physical examination. About 75 percent of the cities, according to this study, employ their school janitors for the entire year rather than for the school term. Butsch (406), in a study of school janitors in Wisconsin, found that the average janitor was employed for twelve months at a salary of \$1,400. Eells (409) made a study of personal data, income, and expenditures of the 75 members of the janitorial and mechanical staff of the Fresno, California, school system. Among his findings were the following: average age, 50; residence in city, 12 years; average tenure to date in the city school system, 6 years; hours worked, 55 per week, annual income, \$1,568 of which 95 percent was received from the board of education.

Parker (427) investigated the social and economic status of 303 school janitors in four states. A comprehensive study of the status of the janitorial engineer was made by a committee of the National Association of Public School Business Officials (404). This committee stressed the importance of the careful selection of men as a necessary prerequisite of training.

According to the most recent data collected by the National Education Association (426), the median salaries paid school janitors are shown in Table 9, and are compared with the median salaries paid teachers.

TABLE 9.—MEDIAN SALARIES PAID SCHOOL JANITORS AND TEACHERS, 1934-35, AFTER THE NATIONAL EDUCATION ASSOCIATION (426)

Population group	Median salary			
	Head janitor	School janitor	Elementary teachers	High-school teachers
Over 100,000.....	\$2,333	\$1,211	\$1,922	\$2,436
30,000 to 100,000.....	1,867	1,233	1,412	1,834
10,000 to 30,000.....	1,348	1,182	1,231	1,603
5,000 to 10,000.....	1,365	949	1,050	1,379
2,500 to 5,000.....	1,362	922	961	1,260

Ganders and Reeves (414) studied the present status as regards age, race, sex, physical health, place of birth, marital status, intelligence, educational qualifications, and experience. The same writers (415) also analyzed the attitude of janitors toward their work and their ability to get along with others. Another study of the status of the school janitor was made by Vander Meer (436). This investigation was confined to the Rocky Mountain region. Reeves and Ganders (430) stated that merit, rather than seniority, should be the basis both for promotion and salary increases, but show, however, that the correlation between salaries and years of experience for all members of the janitorial-engineering service in three cities ranged from .421 to .620.

Training of Janitors

Garber (416) concluded as a result of his study made in 1922 that,

From the loose, careless manner in which a great deal of the janitor service is rendered, it is evident that a large percentage of the janitors are not only ignorant of the principles underlying their work, but of the best methods of performing some of their most elementary duties, such as cleaning, oiling, and care of floors; how to make and use sweeping compounds; proper methods of dusting, washing windows, and cleaning toilets. Instruction that would bring about improvement even in such matters would be of great value in raising health and housekeeping standards, and could be given in any school system.

Garber found, however, that at that time less than 5 percent of the cities attempted to give instruction of any kind to their school janitors. Since that time other cities have started training schools for janitors and doubtless much progress has been made since 1922. Methods of training were described by Hammersley (419), Hallett (418), Womrath (438), Parker (428), and others.

Reeves and Ganders (430) state the principal objectives of courses in janitorial-engineering service as follows:

1. Knowledge of the principles of heating, ventilating, sanitation, and the care of school buildings
2. Knowledge of the correct use of the mechanical equipment of school buildings
3. Knowledge of the best tools, materials, agents, and methods to use in various phases of janitorial-engineering work
4. Skill in using the proper tools, materials, agents, and methods of procedure for the different janitorial-engineering jobs, under varying conditions
5. A scientific attitude in the study of the various phases of janitorial-engineering service, in order to effect the greatest efficiency of results and economy in time and energy
6. Attitudes which will lead to serious, wholehearted, and unselfish attention to the duties of janitorial-engineering service
7. Attitudes which make for harmonious cooperation with pupils and with the administrative, educational, and janitorial-engineering forces
8. Ideals of what constitutes good janitorial-engineering service and of the importance of the service to both the educational work of the school and the protection of school property
9. Appreciation of beauty, harmony, and cleanliness in and about the school building and grounds.

Hoeper (420) attempted to ascertain the need for and trace the development of pre-training of janitors in Missouri schools. He also made recommendations regarding the training of janitors prior to employment. Jenkins (421) devised a self-rating card to aid janitor-engineers to improve themselves in the performance of their duties while in service. McKee (424) prepared a similar self-rating scale.

As a basis for evaluating the efficiency of the work of the janitor-engineer, Engelhardt, Reeves, and Womrath (410) prepared a score card which lists practically all the usual activities and gives a numerical value for each. This card has been supplemented by a compilation of standards upon which the activities are rated (411).

Methods and Equipment

Studies of methods of performing the various activities of operating the school plant which may be properly classified as research are relatively few. Numerous school systems, including Hackensack, New Jersey (417), Minneapolis, Minnesota, (425), and Evansville, Indiana (431), have adopted regulations designed to cover most of the duties of school janitors and engineers; but these have been largely based upon established procedures and by a trial and error process. Carter (407) analyzed 150 sets of rules to determine types of custodial service required by schoolboards. Garber (416) found that there was very little agreement as to definite standards of janitor service in cities.

The United States Bureau of Standards (435) prepared an excellent bulletin which deals with the proper methods of caring for all types of floors. Reeves (429) made probably the most complete study of the

janitor's equipment and methods of work, particularly in the various types of cleaning. The following are some of the conclusions resulting from his study:

1. Vacuum cleaning is superior to brush cleaning in quality of results, speed and economy.
2. Oiled floors from the standpoint of ease and speed of cleaning are superior to unoiled floors.
3. The soft cord duster with handle is more efficient than other types tested.
4. In cleaning glass, a little ammonia or kerosene in water applied with a cheese-cloth and dried with a chamois is better than other methods.

Garber's investigation (416) found that of 1,097 cities, 891 use brush or broom with sweeping compound for cleaning floors; 276 use the oiled brush; 222 use vacuum cleaners; and 366 use two or more of the methods mentioned.

Reeves and Ganders (430) conducted numerous investigations and experiments concerning various methods of performing the varied activities of the school janitor-engineer. They gave a large amount of detailed information on such activities as the cleaning of floors, dusting, care of toilet rooms, cleaning of glass, blackboard and eraser cleaning, operation of heating and ventilating systems, care of school grounds, and care of electrical equipment.

Operating Costs and Economies

Administrators have found one of their greatest difficulties in the incomparability of the financial reports which come before them from other cities. This is due to the fact that the reports are not constructed on the same basis, and classification of items differs. It is thus very difficult to secure meaningful figures on operating costs. Womrath (437) illustrated this by data obtained from reports to the United States Office of Education, which show the total cost per pupil of operation to range from \$4.60 to \$15.69 among a group of cities. Fowlkes, Anderson, and Jones (412) attempted to secure data on the costs of operating supplies in 30 cities located in 18 states. They found considerable difficulty in comparing the data, but concluded that the per capita cost for operating supplies should not be lower than 30 cents nor higher than 60 cents.

Tilt (434) studied the operation and maintenance of school buildings by the contract method in comparison with the regularly employed staff. His conclusions favored employing a regular staff. Linn (422) prepared a checklist designed to determine possible economies in the operation of the school plant. He (423) also suggested six general methods for reducing electric power costs in schools. Schwartzenraub (432) made a study of the cleaning service in the Hamtramck, Michigan, public schools and showed the influence of furniture and equipment upon cleaning costs. Frostic (413) has described equipment that can be used by building employees to avoid expensive plumbing repairs. Boschart (405) also pre-

pared an outline of suggested economies in operating and maintaining school buildings, grounds, and equipment. Swoboda (433) studied the experience of a school district in Pennsylvania in providing its own electrical power. He presented cost data over a four-year period so that comparison with cost of purchased power could be made. He concluded that it was more economical to generate power. Demary (408) made a series of tests of both hand-fired and stoker-fired furnaces with the conclusion that in every case the efficiency of the plants producing power was considerably higher than those where heat only was produced. In only one case did hand-fired plants show an efficiency over 55 percent, with an average of 35 percent. Stoker-equipped plants showed an average efficiency of 72 percent.

Conclusions

That the problems of school plant operation have been seriously neglected is impressed upon anyone who makes a study of them. The personnel responsible for operating school plants have been notoriously inefficient and poorly trained. Little help has been given to them through the medium of research. This seems inconsistent when it is considered that school janitors and engineers are responsible for buildings and equipment costing large amounts of money and that the health and comfort of school children is largely their responsibility. If the studies cited in this chapter seem scattered and in some cases superficial, it should be borne in mind that from the standpoint of research this is largely an unexplored field and each investigator has not had the advantage of numerous other studies of allied problems to assist him.

CHAPTER VII

Types of Construction and Materials as Related to the Original Cost, Maintenance, and Operation of School Buildings

IN THIS COUNTRY and abroad considerable effort is being exerted to maintain the educational efficiency of the schools under reduced budgetary allowances. Schoolhouse planning and construction have received a study and attention in the last decade which assisted materially in maintaining and improving that educational efficiency.

The presentday conception of school planning is the provision of the correct space and facilities for all courses of study and activities to be offered, with the proper relationship between these and with sufficient flexibility in the building arrangement to permit economical building alterations to be made from time to time as the educational program makes such building changes necessary or desirable. A well-conceived plan is one of the most important factors in true economy in school building costs.

The materials used throughout the construction furnish the basis for additional economy, important not only at the time of the construction of the project but throughout the years of utilization of the building, during which wise selection is rewarded by reduced costs for operation and maintenance of the school plant. Herein architects and school building officials are constantly challenged to distinguish between economy and cheapness. Too frequently has occurred the error of striving for a low first cost with the result that the taxpayers are burdened with a building the maintenance and operation of which is disproportionately costly.

Materials used in the construction of a school building are determined principally by the type of architecture and the classification of construction. The Building Code Committee of the United States Department of Commerce named six general types of construction according to the character of the materials employed and the method of assembly. These are:

Type 1—*Fully protected construction* is that in which walls are of masonry or of reinforced concrete and the structural members are of incombustible materials having an ultimate fire resistance sufficient to withstand the hazard involved in the occupancy, but not less than 4 hours for bearing walls, fire walls, party walls, piers, columns, trusses, and for girders which support walls; 2½ hours for walls and girders and for roofs; and in which the degree of fire resistance for other construction features and the materials acceptable for the purpose are as given in the code.

Type 2—*Protected construction* is that in which walls are of masonry or reinforced concrete and the structural members have an ultimate fire resistance of not less than 4 hours for fire walls and party walls; 3 hours for bearing walls, piers, trusses other

than roof trusses, and columns and girders supporting walls; 2 hours for walls, columns, and girders not otherwise specified; 1½ hours for floors, including beams and girders, roof trusses except as provided for in section 11-2-3, and for roofs except as provided for in section 11-8-1; and in which the degree of fire resistance required for other construction features and the materials acceptable for the purpose are as given in the code.

Type 3—*Heavy timber construction* is that in which walls are of masonry or reinforced concrete and the interior framing is of timbers, or in part of protected steel or reinforced concrete having an ultimate fire resistance of at least 1 hour, except for roof trusses as specified in section 11-2-4, the plank floors and roof being arranged in heavy solid masses and smooth flat surfaces, avoiding thin sections, sharp protections, and concealed or inaccessible spaces; and in which the degree of fire resistance required for other construction features and the materials acceptable for the purpose are as given in the code.

Type 4—*Masonry wall and joist construction* is that not included in Type 3 in which the exterior walls are of masonry or reinforced concrete and the interior framing is partly or wholly of wood or unprotected iron or steel.

Type 5—*Wood frame construction* is that in which structural parts and materials are of wood or are dependent upon a wood frame for support, including construction having an incombustible exterior veneer.

Type 6—*Unprotected metal construction* is that in which the imposed loads are carried by an unprotected metal frame and in which the exterior walls and roof are of sheet metal or other incombustible material.

The term "fireproof" has been widely used but inadequately defined with the result that structures varying considerably in fire resistance have been included within the term at various times and places. The Committee believes the terms "fully protected" and "protected" more nearly describe the fire resistance of each type.

With the introduction of numerous new materials, a much wider choice than heretofore is now available. It requires painstaking study and analysis, however, to make the proper selections. A school system which is sufficiently large can, to a certain extent, function as its own laboratory by trial use. Testing laboratories and requirements as set up by the Bureau of Standards and the American Society for Testing Materials would serve as a guide in venturing forth upon some of the new materials.

The proper material for the important structural parts of a building, such as the foundations, the walls, and the skeleton frame, should be selected by the architect or engineer responsible for the design. Opinions will differ as to the respective merits and costs of wall bearing, reinforced concrete skeleton frame, and structural steel skeleton frame types of construction. There is merit in each of these, and the final decision should be made in the light of bearing values of the soil, shape and size of the structure, and cost conditions in the particular vicinity in which the building is to be erected.

There are numerous types of floor and roof construction, many of the newer following the idea of a lesser dead weight, at a subsequently lower cost. In adopting these lighter types, one should consider the likelihood of recurring higher annual cost for fire insurance.

It is reasonable to suppose that floor systems of reinforced concrete would best lend themselves for use in fire-resistive buildings intended for

long-term occupancy. Maintenance of such floor construction, when properly laid, is a minimum. Initial cost, however, is higher than for some of the lighter types of construction.

Frequently the finished flooring for classrooms, as selected by the architect, follows the express wishes of the school authorities. A questionnaire sent to many school systems a few years ago revealed that opinion lay between hard maple and linoleum floors as the first choice. Both possess resiliency and are not too noisy. There appears to be little difference in the cost of caring for these floors year in and year out. If the linoleum is made to conform to the United States Navy specification and is cared for by waxing about three times a year, there seems to be no reason why it would not stand up equally with maple flooring under the same usage. Flooring for other occupancies is selected to withstand the particular usage intended and to permit of easy cleaning. For example, in corridors, the flooring materials possess characteristics of noiselessness. Gymnasium floors afford resiliency, non-slipperiness, and yet are suitable for dancing. Kitchens, shower rooms, toilet rooms, slop sink rooms, and the like have floors of such materials as will permit scalding and flushing with water.

Interior sidewalls in the majority of school buildings are finished with plaster extending from the ceiling to the base. Plaster is finished in either white putty coat or sand finish preparatory for paint to be applied to it from time to time during the lifetime of the building. The wainscot in stairhalls, corridors, toilet rooms, and other special occupancies frequently is built up of masonry units of brick, tile, or terra cotta. Marking upon these is difficult, they can be readily cleaned, and there is little cost for upkeep, although the original cost is somewhat higher than that of plastered walls.

It has become generally known that school buildings of fireproof construction almost always have much of their occupancy unsatisfactory from the point of view of acoustics. There should be incorporated in the specification for construction a schedule of the acoustical materials to be used, principally in the ceilings of the various occupancies, the type and amount for each depending upon the particular occupancy. While such treatment is somewhat more costly than ordinary plastering, if properly done at the time of construction, it will obviate the need for going back into these rooms after the school has been put into use and attempting to correct each room by the application of a material over what was originally intended to be the finished surface.

The type of windows to a considerable extent is dictated by the architectural design. These may be of either the double hung or the projecting type, in wood or in metal. Climatic conditions enter largely into the correct selection. Where play space is somewhat restricted and the danger of glass breakage consequently increased, such glass replacement would be held down in cost by a design which cuts up the sash into six or more lights.

The interior trim throughout the building is preferably of a hard wood, finished in such a manner as to reveal the beauty of the grain and to permit

of easy and rapid dusting. The experienced schoolhouse architect designs the interior free from ledges and projecting surfaces, simplifying the moldings, panels, etc., and achieving beauty by simplicity of line. This makes it possible for the cleaning force to do a thorough job of removing the dust after sweeping each day, without too much effort, thus affording a higher degree of sanitation.

The toilet rooms of a school building offer the greatest challenge in the selection of satisfactory materials. By arranging the terrazzo or tile floors in boys' toilet rooms to pitch to a battery of china stall urinals, it would be possible to flush these with a hose during the noon recess and again after school from hot and cold water connections provided in each toilet room. With daily attention to this and with the usual system of mechanical exhaust from toilet rooms, there is evidence that these rooms can be kept as clean and odorless as they were when newly constructed.

Toilet partitions of marble or similar material are ideal. Although the first cost is high, they require little maintenance and do not lend themselves to pernicious marking. Thick wire glass partitions with hammered surface, engaged in a metal frame, while not free from maintenance like marble, nevertheless have the advantage of being unsuited for marking and permit the diffusion of light throughout each toilet compartment.

In elementary schools the placement of wash basins in a recess in the corridor just outside the toilet rooms materially lessens the amount of cleaning to be done and reduces the number of stoppages in sewerage lines.

Stairs obviously show usage more quickly than almost any other part of the building. Because of this there are special precautions to be taken in selecting the materials making up the finished treads. The manner in which the stairs are placed in the building, whether or not they are enclosed in a stair tower or hall would affect the final decision since, if these are enclosed somewhat from the rest of the building, the noise emanating from them will not be so objectionable. In such cases, metal, hardened concrete, stone, slate or tile treads can be used. If a quieter tread is desired, these may have fillers of mastic, asphalt, rubber tile, or linoleum back of a safety nosing.

An opportunity to effect substantial economies exists in the mechanical services. Too frequently are found leaky steam connections, dripping faucets, and poor traps, all of which permit of a loss each hour they remain in disrepair. The total annual loss easily becomes one of considerable magnitude.

Surely there is no economy in adopting a policy of designing the sizes of mechanical services only to the limit of present working capacity, since changes in the curriculum invariably make additional mechanical services necessary as time passes, and ordinary usage soon takes its toll in efficiency. Pipes and fittings through which hot water flows should be made of brass or copper to avoid the probability of replacement in the next decade. Drain lines from sinks in laboratory or shop, where any reasonable opportunity exists for acids to be dumped in them, should be made of special

acid-resistive materials. Even though these cost considerably more than ordinary drainage pipe and fittings, the increased expenditure would prove an economy. High-grade faucets and valves prevent frequent repairs. The alternative is wasted steam and water.

The Board of Fire Underwriters, through its nationwide inspection, controls to a considerable extent the kind of materials used and the installation of electric wiring. The amount of light to be provided is not their concern, however. As in cases of other mechanical services, it will again be found economical to provide a switchboard and main and branch feeders of a capacity beyond the requirements of the first design so as to have available spare circuits for the subsequent installation of additional instructional equipment which would make possible alterations to the school building as the years go by, in order to meet the changes in the courses of study that are constantly taking place.

A sizeable proportion of the operation costs in most schools is represented in fuel for heating. The architect should, therefore, design the exterior walls and roof with an exact knowledge as to the extreme temperatures to be met in the locality. Rapid heat transfer through walls and roof constitute a considerable waste. These should be designed against such conditions and thus make the building more comfortable also in warm weather.

There are two or three important factors in the selection of the materials for the exterior of the building, the nature of which must necessarily be determined by the architect so as to be properly related to the design. Where masonry units are used, mortar becomes of great importance. No attempt should be made to economize here; otherwise there will be shrinkage, causing wall leakage and subsequent disintegration not only of the mortar but of the masonry units themselves. The flashing of walls to prevent passage of water through them in a vertical direction is receiving much attention where high-grade construction is wanted. Such flashing, properly applied, largely prevents disintegration of mortar joints, efflorescence, and damp walls and floors.

Careful consideration should be given the selection of the roofing materials. These depend upon the character of roof and type of architecture. They should be of good materials of such construction as to permit readily finding leaks from the outside or inside, and with all metal work in connection therewith made of copper or zinc, if it is desired to keep maintenance costs at a minimum.

In conclusion, experiences of those continuously engaged in the operation and maintenance of large school properties indicate the wisdom of making higher initial investments in many materials and articles of equipment which are required to stand up under the heavy wear and tear to which the average public school building is subjected.

CHAPTER VIII

Plant Development for Higher Education, Including Junior Colleges

RESEARCH in the field of college and university building planning has been less extensive than in the case of the public elementary- and secondary-school plant. There have been relatively few generalized attacks on the major problems involved. Study has been confined for the most part to the individual building projects of specific institutions. Nevertheless, a surprisingly voluminous literature has developed. Workers in this field are indebted to the painstakingly collected bibliographical compendium of H. L. Smith and Noffsinger (623) which cites, classifies, and briefly annotates over two thousand references on college and university buildings, grounds, and equipment. A perusal of this bibliography, however, discloses the fact that over 80 percent of these entries go no farther than to reproduce floor plans and photographs and describe them more or less briefly. There are only a very limited number of studies which could properly be characterized as research.

The most important publications in the field of college plant planning are two volumes sponsored by the Association of American Colleges through its Commission on College Architecture and College Instruction in Fine Arts. The first, *College Architecture in America* by Klauder and Wise (553), was published as a joint undertaking of this commission and the Carnegie Corporation. It contains a historical treatment of early college buildings, an extensive survey of general campus development plans, and detailed discussions of administration and academic buildings, libraries, chapels, auditoriums, dormitories, dining-halls, museums, and buildings for science, engineering, art, athletics, student welfare, and plant operation and maintenance. It emphasizes principles and standards of planning and is copiously illustrated with photographs and floor plans.

The second volume is *Architectural Planning of the American College* by Larson and Palmer (560). It grew out of the work of the architectural advisory bureau at the headquarters of the association, and devotes major attention to the liberal arts college. The association had built up a large collection of data on recently constructed college buildings and the authors had served in an advisory capacity to a number of institutions confronting building problems. The report follows much the same pattern as the first volume, with extended discussions of character in college architecture and an excellent analysis of relationships between architect and college. Various types of specialized college buildings are presented with a wide variety of illustrative material.

Representative of general surveys of university plants is the volume by Reeves and others (603) in the University of Chicago Survey. Appraisals were made of site, service facilities, recitation and lecture rooms, laboratories, and offices. Both buildings and classrooms were rated by brief score cards. Natural lighting was reported more inadequate than artificial lighting, and on a general room rating, 89 percent of the classrooms were reported either satisfactory or potentially satisfactory. The average amount of office floor space for professors was 207 square feet; for associate professors, 182 square feet. An extended analysis was made of the utilization of classroom space. On the average, 95 classrooms in 15 buildings were utilized 59.3 percent of the total possible periods during an eight-hour day. On the basis of a 44-period week, the percent of utilization dropped to 17.6. Recommendations include the provision by partitioning of a larger proportion of small classrooms and the abandonment or conversion of some classroom space.

Other examples of general plant surveys are those by Reeves and others (601) and the Maine higher education survey (466). The first tabulated and discussed a wide range of factual material on the physical condition of 345 buildings on 35 campuses of institutions under the jurisdiction of the Board of Education of the Methodist Episcopal Church. There is a comprehensive analysis of building utilization, and recommendations are made in terms of generally accepted standards. An estimate of \$20,000,000 is made as the amount of new construction necessary to furnish adequate housing for these 35 colleges. The Maine Survey (466) is somewhat unique in that it utilized as the basis for plant analysis the score card technic. The four institutions surveyed scored 377, 567, 618, and 644 out of a possible score of 1,000. Recommendations for plant improvement and extension were made in terms of the objective data provided by the scoring.

Evenden (499, 501), in collaboration with Strayer and Engelhardt, has applied the scoring technic originally developed for public school buildings to college buildings and to the physical plant of normal schools and teachers colleges. The scores are to be recorded on the basis of standards outlined in bulletins. The weighted scores for individual items are in fives or multiples of five. The 1,000 points on the college card are distributed: site, 140; buildings, 160; service systems, 185; instruction rooms, 280; general units, 235. For teacher-training institutions, the distribution is: site, 110; buildings, 155; service systems, 175; instruction rooms, 220; practice schoolrooms, 180; general units, 160.

College library planning is most adequately treated by Gerould (508), librarian of Princeton University, whose material is based on personal visitation to fifty representative colleges. The experience of these institutions is critically evaluated and general principles and standards set up and discussed for all major phases of library planning. He recommended centralized housing of all collections. Ample provisions must be made

both immediately and in flexible plans for enlargement for four major services: undergraduate study, study by advanced students or faculty, the administrative work of the library staff, and the shelving and storage of books. He recommended also minimum reading-room accommodation for 30 percent of the student body and stack room for at least twice the number of books in the library when the building is opened. The discussion is characterized throughout by a wealth of specific and detailed suggestions on all important issues.

Turner (642) provided an interesting series of plan types of college and university libraries, including several from Canadian and English institutions.

McHale and Speek (571) reported a series of papers presented at a conference on housing college students, covering dormitory design and planning, equipment, food service, and financing. They also contain brief descriptions of housing plans at a number of institutions and special reports on the newer housing plans commonly called cooperative houses, designed to reduce students' expenses.

Hayes (529) discussed suggested standards and recommended procedures for all phases of planning of student residence halls. A critical summary of existing standards was provided and specific advice given on the general planning process, site, size, floor plans, staff accommodations, social life, food preparation and service, safety and welfare provision, floors, walls, heating, ventilation, and lighting.

Bryan and Handy (472) outlined requirements and specifications for the furnishings and equipment of residence halls.

Facilities for practice or laboratory schools in connection with the teacher-training programs of colleges were treated by Mead (574, 575, 576, 577) and Wrigley (657). Mead presented data on the cost of present schools and deficiencies in their design and layout. Wrigley's study was confined to the training school plants of the state teachers colleges in Pennsylvania. He found no institution with adequate facilities and made numerous suggestions for improvement.

Hamon (523) made the most extensive analysis of utilization of college instruction rooms. He gathered and classified data on 1,393 classrooms in 22 colleges by type of institution, type of room, period of day, and weekly load. He found heavier use of recitation and lecture rooms in the periods before lunch, and a correspondingly heavier load on laboratories in the periods after lunch. He showed somewhat higher utilization measures for teachers colleges than for other types of institutions.

Knox (556) outlined a comparative cost analysis of four similar university classroom buildings constructed in the same geographical area from 1928 to 1934 and varying in cost from sixty-eight to thirty-one cents per cubic foot. The analysis was broken down by foundations and framework, exterior facias, roof coverings and interior partitions, interior finishes and surfacing, mechanical and electrical equipment, and general equipment. He tabulated in detail the structural features and schedules

of finishes and showed plan and elevation sketches. This illustrates a usable technic of cost comparison.

Joyal (546) developed the following minimum standards for the establishment of a junior college: area with radius of twenty miles, minimum high school with average daily attendance of 1,250, minimum junior college with average daily attendance of 200, eight full-time teachers, 120 periods of work per week, and \$16,000 per year for current expense.

Junior college housing has been studied intensively in doctoral dissertations by Chamberlain (477) and Hardesty (526). Data for the first were gathered by personal visitation to thirty junior colleges located in Illinois, Iowa, Kansas, Michigan, Minnesota, and Missouri, with a range of enrolment from 21 to 759 and a median of 108. Two were housed separately, fifteen were classified as joint housing with partial segregation by floor or wing with certain rooms reserved for college work, and thirteen were housed jointly with other units without special effort at segregation of college classes. A detailed classification of the building facilities available and in use is made by type of room. As factors in the prediction of enrolment, a public junior college will on the average have a freshman enrolment approximately 50 percent of the twelfth-grade enrolment for the previous year in the same system. The total enrolment will approximate 12.8 percent of the total high-school enrolment. The sophomore enrolment will approximate 50 percent of the freshman enrolment. There is a significant negative relationship between the size of the fee charged and the enrolment. The number of room-periods per week will approximate 110 percent of the enrolment and will be distributed 62 percent for academic and 38 percent for non-academic work. With respect to administrative organization, it is recommended that the junior college and high school be under the control of a single individual responsible to the school superintendent, that periods be uniform for both, and that the 6-4-4 organization be set up as the ultimate objective. Dual housing and joint use of facilities by high school and junior college is the trend. The facilities required for "a reasonable program of studies at an effective junior college, in the light of present practice" would include a laboratory or laboratories equipped for offering instruction in general inorganic chemistry, qualitative analysis, quantitative analysis, and organic chemistry; a drawing room with facilities adequate for work in beginning engineering drawing, descriptive geometry, and advanced drafting; a woodworking and pattern shop; a foundry; a machine shop; a forge room; a physics laboratory equipped for offering work in mechanics, sound, heat, light, magnetism, and electricity; a biology laboratory equipped for giving instruction in general zoology and general botany; an accounting room; an electrical laboratory; a gymnasium and the field facilities necessary to offering the physical education work generally required of college freshmen and sophomores; lecture rooms for chemistry, physics, biology, and electricity; and academic rooms, administrative offices, library and study room, an assembly or auditorium,

and facilities for college athletics, including a gymnasium, an athletic field, and, under standard conditions, a swimming pool, club rooms, and a publications room.

Complete and detailed standards are set up for all regular and special facilities. The study indicates that reasonably adequate housing is unlikely in any situation with a junior college enrolment of less than one hundred.

Hardesty (526) made a similar investigation of thirty-two California junior colleges, with a median enrolment of 400, which is four times larger than the median in Chamberlain's group. The differences in findings and recommendations are due largely to this difference in size. Four major functions of the junior college are discussed, i. e., guidance, terminal, preparatory, and adult education. Present housing conditions handicap adequate curriculum offerings, mainly in the field of work of a terminal vocational nature. A range in class size is reported from 1 to 324, with a median of 26. Median class size distributed by subjectmatter ranges from 16 in music to 37 in social studies. The following numbers are suggested for desirable, maximum, and minimum class size in the junior college:

Physical education, 50, 65, 15
Social studies, 45, 60, 15
Commerce, 40, 55, 15
English and science, 35, 50, 15
Foreign language, mathematics, art, and music, 30, 45, 15
Engineering, 25, 40, 15

A formula is presented as follows for determining the pupil-station capacity of a classroom:

$$PSC = \frac{RW - AW}{PSW} \times \frac{RL - ISD}{PSD}$$

PSC = pupil-station capacity, RW = room width, AW = aisle width, RL = room length, ISD = instructional-space depth, PSD = pupil-station depth.

To determine the length of a classroom, to accommodate a given number of pupil stations:

$$RL = \frac{PSC \times PSW \times PSD}{RW - AW} + ISD$$

Special attention is given to the requirements for library, auditorium, cafeteria, lockers, office needs, size of site, and location. Separate housing is preferred by 90 percent of the administrative officers in this study. Where dual housing is necessary, the consensus of opinion favors complete or partial segregation of the junior college classes in a particular wing or floor or building with certain rooms reserved specifically for junior college work; separate study facilities with either a combined or a separate library; combined administrative officers; dual extracurriculum activities and student-activity program; and same length periods for junior college and high school.

CHAPTER IX

Recent Trends in School-Plant Planning¹

THE REPORT of the Commission on the Social Studies of the American Historical Association (660) declared that if the school is to justify its maintenance and assume its responsibilities, it must recognize the new world order and proceed to equip the rising generation to cooperate effectively in the increasingly interdependent society and to live rationally and well within its limitations and possibilities. Whatever may be the exact character of life in the society now emerging, it will certainly be different in important respects from that of the past. Kilpatrick (684) stated that our schools are changing, and that everyone in middle life can see how different the schools are now from those of his youth. Melvin (689) pointed out that the new school actually looks different from the old one. It is a walking-about school rather than a sitting-down one. The children may be doing anything that is good for them to do. It is not an institution run by rule and regulation, but a community of self-determining children, busying themselves about dozens of things. The new school is not a room with rows of seats where children stay still by the hour, but on the contrary it is a social organism in which the individual has great freedom to develop in and about buildings, around town, and often outdoors in the country. Moehlman (692) predicted that so long as social change continues, public education needs will also change, for they are at all times only a reflection of the community life about us. A changed public school has brought about changes in the school plant. An examination of the educational research covering the past few years seems to indicate the following significant trends in school-plant planning.

National Planning

The final report of the National Planning Board (696:30) gave these reasons for planning: (a) the necessity and value of coordinating our national and local policies instead of allowing them to drift apart, or pull against each other with disastrous effect; (b) the value of looking forward in national life, of organized preventive policies as well as remedial, or preventing the fire rather than putting it out; and (c) the value of basing plans upon the most competent collection and analysis of the facts. While the report does not mention schools specifically, it emphasizes the necessity for a wise and orderly procedure in regard to all governmental activities. Wise planning is based on control of certain strategic points in

¹ This chapter was prepared under the supervision of Dr. N. L. Engelhardt, Teachers College, Columbia University, New York, N. Y.

a working system—those points necessary to insure order, justice, and promote the general welfare. It assumes that the gains of civilization are essentially mass gains and should be enjoyed by the whole people who created them, rather than by special classes or persons. Beard (663) wrote that no government or society as a whole can escape the impact of this planning process. Laidler (686) pointed out that this nation on entering the World War really developed a national plan. Overnight the government created a skeletonized collectivist society. The railroad, the telephones, and the telegraph systems were brought under federal control. The policy of laissez faire was held in abeyance, and leaders from Washington did much to fit the plans of each one of the basic industries into a larger national scheme. Viles (708) urged the adoption of a national schoolhousing program. He cited four reasons for such a move:

1. Federal funds are needed to build rural schoolhouses in certain areas.
2. The funds should be given on the basis of an outright grant, the same as for roads.
3. Federal funds should be provided only after a survey has been made and the need established.
4. The aim of the program should be to set up desirable school units.

In December, 1934 a conference on state school legislation and long-time educational planning was held in Washington, D. C., under the auspices of the Joint Commission on the Emergency in Education. The purpose of the meeting was to bring together a representative body of American educational leaders to consider the problems of education in relation to our political, economic, and social structure. School-plant planning was one of the topics that received careful consideration.

Relation of City Planning to School-Plant Planning

After studying the relationship that has existed between city planning and school-plant planning, and showing the need for a greater cooperation, R. A. Holy (682:155) made the following recommendations:

1. It is within the sphere of competency of the school authorities to initiate city planning and zoning movements.
2. The school needs of the community should constitute a principal consideration in the preparation of any city plan or zoning scheme.
3. The city plan and zoning regulations should function as the framework for the school plan.
4. The activities of the zoning and planning authorities on the one hand and the school authorities on the other should be carefully coordinated.
5. Provision should be made for easy exchange of all items of information which can be prepared by one planning body and are needed for the proper functioning of the other.

The study pointed out the ultimate relationship that should exist between city and school-plant planning if either is to accomplish its end. In spite of the need for a close relationship, there has been very little effort to coordinate the work and such lack of coordination has resulted in frequent and costly mistakes. The study further showed the importance of

school-plant planning and city planning being advanced concurrently at all times. The school-plant program should be a definite part of the city plan and its treatment should be from the point of view of the educator. The organized planning of the future will undoubtedly deal more and more with the relationship of all community activities and with the relationship that should exist between urban communities and suburban and rural areas. It will be necessary for all individuals and agencies interested in planning to cooperate to secure the desired ends, because city and school planning officials have ultimately a common goal—the welfare and betterment of the community and its citizenry.

The part which the state should play in school-plant planning was pointed out by Hill (681). Some of the basic principles behind the agitation for school-planning departments were: (a) school administrators have placed the emphasis on the essentials of administration and teaching; (b) education has not been able to interpret its needs to the architects; (c) standards should be set up that would prevent the building of unsatisfactory school buildings; and (d) architects do not always interpret the instructional programs.

The National Advisory Council on School Building Problems was organized by the United States Office of Education in 1929 for the purpose of providing a clearing-house of information on all problems relating to the planning and construction of school buildings (662). School building exhibits, showing trends in school building construction, have been held in various sections of the country.

A Functional School Plant

That significant changes in school-plant planning have taken place during the past century is clearly brought out in Long's study (688). He pointed out, however, that changes in curriculum were not visible in schoolhouse architecture prior to 1900 other than the building of classrooms for each grade. School building programs during the twentieth century have lagged far behind the needs of curriculums. Even today school buildings are constructed that are copies of those built about a century ago. Long's study indicates that there is now a tendency to make elementary schoolhouses more flexible. More of them are being provided with auditoriums, gymnasiums, and special rooms. Most presentday school buildings are not good examples of functional plants, and the literature of the field seems to indicate there is general agreement with Long when he (688:32-33) says:

No doubt some of the more alert and progressive school administrators have become aware of the environmental needs of the modern elementary school curriculum, but up to the present time few school plants have been erected that provide adequate facilities for carrying out the more progressive type of education. We should be able to look forward to having more aid given to the development of a suitable educational program through buildings, equipment, and grounds planned specifically for the purpose which they are to fulfill.

Long's study of twenty progressive schools indicated that there was scant provision for flexibility and expansibility. He concluded that flexibility should enter into the provision made for service facilities. Better results would likely be obtained if the teachers, supervisors, and principals were allowed to participate in the planning and equipping of school buildings.

Hamon (677) indicated that the purpose of a school plant is to house a school program. In planning a school plant the dominating motive should be to provide for the child and his needs. The building should provide a healthful environment, should be architecturally pleasing, and should serve the functions which it houses. Correct planning requires the services of a superintendent who has an educational philosophy, as well as the services of an architect and an engineer. The report of a sub-committee of the White House Conference on Child Health and Protection (711) stated that the first responsibility of the school authorities is to provide a healthful environment for the child while in school. School-houses should promote health rather than undermine it.

In his study of space provisions in seventy-two school buildings, Spohn (704) found the following trends:

1. A greater variety of space provisions
2. A trend away from separate laboratories for specialized science subjects
3. An increase in the provisions for home economics and commercial subjects
4. Larger space provisions for more specific types of shop work of a practical nature
5. More adequate facilities for an expanded physical education program
6. Separate rest rooms for teachers
7. More adequate office facilities tending toward a general office suite
8. A tendency away from general storage to specific storage rooms
9. More consideration being given to janitors' rooms, fireproof vaults, motion-picture booths, waiting rooms, club rooms, conference rooms, museum, armory, band room, and auditoriums as practice rooms.

An examination of Vischer's *Der Neue Schulbau* (709) indicates that changes in the school plant have taken place in Germany similar to those that have occurred in the United States. Some of the changes as indicated by Vischer are:

1. The expansion of the content of the course of study
2. A wider use of technical inventions to aid and supplement instruction
3. A greater attention to health and the physical comforts of the children.

In order to provide for these changes more flexible school plants have been provided.

Adaptation of the School Plant To Serve the Social, Recreational, and Educational Needs of the Community

That the school should assume a larger role in the social, recreational, and educational life of the community is accepted by most writers on the subject. Engelhardt (667) pointed out that the schoolhouse in the past

has very frequently been thought of as a structure in which children were protected and safeguarded from the life of the community. The school-house of the future should be visioned in different terms. He stated:

It should be a community center, not only for keeping children under control and remote from the realities of life, but also a community center in which children and adults discuss the common purpose of the society in which they live and organize the principles according to which individuals must associate with the other members of society.

While it is generally assumed that the school should occupy a very important place in the life of the community, Prueett (699) found that the social and community uses of the school plant were given the least emphasis in the general standardization program, as less than 1 percent of the total items mentioned pertained to the local use of the school plant. According to Morgan (694), a community will use the school plant in a definite and constructive manner provided the school authorities will point the way. The school-community relationships really take on two forms: (a) those activities provided within the school's walls and on its premises in which the community at large may participate; and (b) the development of school activities that may be carried out from the school into community groups to enrich social life.

Harrison and Dobbin (679) emphasized a wider use of the school plant and stated that it is important to take into account the fact that the school of the future will not be a building that is used for only six hours a day, but rather it will be put to valuable use at least sixteen hours out of each twenty-four, and it will eventually develop that the greater portion of the rooms will be used for assemblies, demonstrations, and physical culture. Moehlman (691) suggested a broader conception of the use of the school plant and urged that all school buildings of the future be designed by educational specialists around the curriculum and extracurriculum needs of the child and the adult life of the community. Thompson (707) illustrated how a board of education showed foresight in planning a new structure that would provide for the increased school population and at the same time offer accommodations for certain community projects.

Moehlman (693) also stated that no school building should be located without first making an actual survey of the needs of the community. Since school buildings should be built to serve for fifty years, it is very important that they be properly located. It is no more extravagant to build high quality schools than it is to build high quality homes. If the school plant is to serve the needs of the local community, it must be flexible and expandable. Spain, Moehlman, and Frostic (703) even went so far as to say that the measurement of the physical efficiency of the school plant is best expressed in terms of flexibility, expansibility, freedom from hazards, traffic area, health requirements, and use and location in district to be served. Schmidt (701) suggested that new constructions must afford a maximum of flexibility in arrangement and permit such additions and changes as the future may demand. All original plans should include the

probable future additions. Engelhardt (672) described an open-air school of Milan, Italy as being provided with school buildings and dormitories, lunch rooms, a chapel, a model home, a model stable, a model poultry yard, model fish ponds, running tracks, and swimming pools. It also contained vegetable gardens, fruit orchards, small experimental fields, flower gardens, vineyards, and lawns. The school buildings themselves are one-story, of four classrooms, each located in various parts of the grounds. All of the facilities of the institution are used for instructional purposes. Physically handicapped children live in it.

Flexibility

T. C. Holy and Arnold (683), writing on flexibility, stated that:

Since it is not possible to foresee all the requirements of the future, every school building should be so planned and constructed that changes can be made when necessary in the length and arrangement of the rooms. A great amount of flexibility is secured through the "unit type" of construction which enables partitions at the end of rooms to be easily removed or changed. Heat and ventilating ducts, pipes, electric wires and switches, doors and windows should be placed in side walls of rooms in units of five, ten, or more feet in such a manner as to offer no difficulties in enlarging or reducing the length of any room. Equipment should be installed so as to make changes as easily as possible. Built-in facilities should not be so specialized as to make it difficult to readapt the rooms for other purposes.

Hart (680) also pointed out that flexibility in classroom size and arrangement is an extremely desirable feature of the school building in a growing community and that movable partitions give flexibility to classrooms. Shigley (702) stated that school buildings should be planned from the ground up so that they may be made to meet new demands. The classrooms should be flexible so that they may be made larger, if need be. He further showed that the new schools of New Britain, Connecticut, are planned for flexibility.

Hamon (678) emphasized the adaptation of the room to the number and size of the occupants, and the equipment and materials necessary to the desired activities of the occupants. He also said that some of the modern educational ideas which tend to influence the type of building to be built are: (a) socialization of the class period; (b) greater use of the basic muscles in handling large materials; (c) greater use of visual aids; (d) use of objective tests; (e) extension of the program to include music, art, elementary science, health, physical education, and the prevocational activities; (f) emphasis on extracurriculum activities; and (g) the changes in the school buildings necessary to meet the needs for kindergartens, high schools, junior high schools, and junior colleges. He maintained that the traditional room is not satisfactory to meet these changes. We must plan for an economical means of altering the room length, since that is about the only way to secure much flexibility in permanent school buildings. The children in the public school now handle much more educational materials in their work than formerly. Therefore, ample pro-

vision must be made for plenty of built-in space in the form of shelves, closets, cabinets, racks, etc.

Butterworth (664) made a study of special-room facilities in superior consolidated schools and found that most of the schools were fairly well equipped with rooms for some of the special work but especially lacking in some of the newer subjects. He found that the facilities for health education were very meager. There were no open-air rooms and only one building had a dentist's room. Fewer than one-fourth had a nurse or a school physician's office. Vocational rooms were much more prevalent than health rooms. Nine-tenths had facilities for homemaking classes, four-fifths had rooms for agriculture, one-half had rooms for commercial work, and two-thirds had woodworking rooms.

A Clarification of School Building Problems

On reviewing the thirty-third yearbook, part one, of the National Society for the Study of Education (697), one is cognizant of the scope of school building problems which are being uncovered and clarified by research studies. This yearbook presents a composite of expert judgment and in some parts some objective data. Those responsible for building school-houses may get from this yearbook valuable suggestions about policies, about planning, and about the interrelations of all the agencies involved in school building programs. The yearbook is divided into six sections treating thirty-four pertinent problems in school-plant planning. The titles of the sections are:

1. The Philosophy of the School Plant
2. School-Plant Planning Policies
3. Educational Services
4. Architectural Services
5. Constructional Service
6. Financial Aspects of the Problem.

Through an analysis of the school building problems in ten American cities in 1928, Engelhardt (670) clarified the specific tasks that are involved in school building programs. Surveys of the school building needs in these cities served as bases for specific recommendations for new buildings. This book, as well as many other studies, seems to indicate that the tendency is for a comprehensive school survey to serve as a basis for school building programs. Strayer and Engelhardt over a period of years have isolated many of the specific problems involved in school building programs. The standards developed by them for elementary-school buildings (705) and high-school buildings (706) set forth clearly many of the specific problems. These, with their accompanying score cards, may be used to great advantage in arriving at the scope of a school building program.

That important trends in school-plant planning have taken place was brought out by Engelhardt (671).

Special emphasis has been placed upon certain items which have not been given much consideration in the past. These items include such features as ample parking spaces for automobiles; the acoustics of classrooms, corridors and special rooms; provisions for radio and audio-visual education; kinds of lockers and types of locking devices; movable and built-in equipment in classrooms; the inclusion of an audio-visual studio; and emphasis upon specialized equipment for special laboratories and classrooms.

The lack of provision for many of the specific items of cost in school building programs was brought out by Misner (690). He discovered in his investigation that extra-cost items (items not included in the original contracts) and incidental costs (those which are not a part of the building's operations themselves) often result in a great waste of money for the community. By pointing out poor procedures in the planning and execution of school building programs, the use of this study should aid school officials in spending wisely the money appropriated for school building purposes. Misner developed a checklist of extra-cost items not covered in unit prices. He discovered that back of the excessive extra costs were:

1. Insufficient importance attached to work of an educational nature by the board of education
2. Boards placed too much emphasis on low estimations made by competing architects
3. Architects were allowed insufficient time between selection and the letting of contracts
4. Development of building plans without sufficient advice from educators.

Byrne (665) has done much toward the isolation of detailed problems of school building in his checklist of school building specifications. Although one may find the use of this checklist a rather tedious task, valuable suggestions for those responsible for school building specifications can be secured from it. Perhaps the most valuable contributions of this research are the guidance it gives by example and by pointing the way to further needs of scientific analyses of numerous problems involved in school building programs. The standardization of the various kinds of equipment used in school building construction should not be left to the manufacturers. A great deal more should be known about the personnel having the responsibility for writing school building specifications. Byrne's study is an example of many that will be made before schoolhouses can be constructed and equipped throughout on the basis of scientific information.

Standardization of School Plant Requirements

Standardization of schools was treated by Prueett (699). He found that rural and elementary standardization existed in thirty-five states. Each one of the thirty-five states included some items of the school plant in its standardization program, with the number of items ranging from 27 in Pennsylvania to 248 in Wisconsin. He found a total of 3,486 items of standards relating to school plants in the rural elementary standardization

programs in the thirty-five states. There were 354 statements in the program of high-school accrediting agencies relating to the elementary-school plant. Of the total of 3,839 items he found 2,242 statements not duplicated by any two states. By far the largest number of items related to "Substances for the Sustenance of Life," such as air, light, water, and heat. Less than 1 percent of the total referred to the school plant. The standards used were largely subjective as is shown by the use of adjectives and adverbs. The word "good" appeared 236 times in the standards he examined.

High-school accrediting is practiced in all states except Nevada. High-school standards contain items relating to the school plant ranging from 8 in Virginia to 530 in Pennsylvania, or a total of 3,182. Of this number 2,407 are not duplicates. Approximately one-third of all items related to teaching equipment. Pruett also found that there was a close correlation between elementary- and high-school standards, the correlation being .7111. There was considerable duplication in the work of departments of state in matters pertaining to the school plant and he recommended that the work of standardization, or accrediting schools, be made by the state department as a whole and only when schools had done unusual or meritorious work in carrying out a well-rounded program formulated by the entire department.

Standardization of some phases of the school plant itself has been going on quite rapidly, as indicated by part one of the thirty-third yearbook of the National Society for the Study of Education (697). Thirty-eight states provided some form of legal approval of plans and specifications for public school buildings. In nineteen states it was required that all plans and specifications for school buildings be approved by some state agency. In the remaining sixteen states the state control does not begin until the cost of the structure exceeds a prescribed minimal amount ranging from \$300 to \$5,000.

Proctor's study (698) revealed the need for state supervision in the checking of architect's working drawings before the school buildings are allowed to be erected. He came to the conclusion that only through such state supervision of the school building program would the rights of the child be safeguarded and the taxpayers be assured of the most economical expenditure of the public funds. He further concluded that it is far more economical and far more desirable to supervise the making of the plans and the working drawings than to attempt to get results by inspecting the building after it is erected.

Sahlstrom (700), after studying (a) the status of the schoolhouse in municipal building codes; (b) the municipal code requirements for fire resistance in school buildings; and (c) the municipal code requirements for stairways, fire escapes, bearing walls, live floor loads, and sanitation, came to the conclusion that the state should gradually assume the responsibility for the supervision, management, and control of public school building construction. He came to this conclusion because (a) the muni-

cipal building codes generally failed to secure the differentiation of requirement so essential to the needs of individual types of buildings; (b) a majority of the school building ordinances failed in a conspicuous way to recognize the school as an individual structure with use and occupancy characteristics peculiarly its own; and (c) the attempt to classify the school with other more or less related buildings, and to govern the construction of school buildings under general requirements resulted in a loss in building efficiency, excessive costs in construction, and increased hazards to the life and health of the school children.

A Larger School Plant

Engelhardt and Engelhardt (668) stated that large units centrally located can serve the school population more economically and efficiently than can small units scattered throughout the community and housing only small numbers. There has been a distinct trend toward larger and more central schools. Statewide surveys like those in Missouri, Alabama, and Florida have clearly indicated that there are too many small schoolhouses. A. F. Harman, while state superintendent of schools in Alabama, carried forward a splendid program with respect to location, planning, and erection of school buildings. In Maryland, under the leadership of State Superintendent Albert S. Cook, standards for the location and erection of buildings have been very widely accepted and followed. Practically the entire rural plant of Delaware has been changed within the past ten years.

Altstetter (659) showed that there are larger classes and that they are here to stay. Larger classes mean larger classrooms which seriously affect school building plans. Rooms should be wider as well as longer in order to handle the larger numbers, which means that the problem of artificial lighting looms large. Frederick (674) emphasized four distinct high-school trends: (a) small high schools of fewer than 100 pupils will disappear as transportation facilities improve and the population moves from marginal lands; (b) the high school of the future will tend more and more to become a community high school in the sense that it will take a more definite part in and draw more extensively on the life of the community by which it is supported; (c) the six-year secondary school will become more frequent in smaller communities; and (d) in the high school of the future will be found 90 percent of the children of high-school age unless the CCC idea or the militarists offer greater inducements to the youth of the land.

Significant progress has been made during the past few years in the planning and building of schoolhouses. Much of the impetus has come from the initiation of professional courses in schools of education for the training of school executives in all fields of school management. An additional impetus has come from the survey movement. Recent school building surveys indicate that the theoretical development of standards has moved ahead far more rapidly than the acceptance of those standards and their incorporation in new construction.

Capital Outlay Expenditures

Grossnickle (675) discussed the relation of the state's minimum education program to capital outlay. He showed that at present there is no statewide plan in operation which equalizes capital outlay, although means by which a state may equalize for these purposes were suggested by Adams (658), Baldwin (661), Mort (695), and Weller (710). Grossnickle's study (675) grew out of an assumption made by Mort that there is a constant relationship between current expense and capital outlay. He came to the conclusion that regardless of the type of program offered, the ratio between debt service and current expense remained constant.

Moehlman (691) added that it is necessary to keep our credit clear so that we may save our borrowing power for time of need and operate our schools at full power during depression periods. He further stated that the best solution for financing buildings is to enter upon a complete pay-as-you-go program as soon as possible. Since present school districts are much too small for this policy, he suggested that the state make provision for the financing of the public school plant through moneys raised by current taxation. Essex (673) showed that the number of school districts using the pay-as-you-go plan increased slightly, from 28 percent in 1923, to 37.8 percent in 1927. He further stated that it will be impossible for all districts to adopt any one plan in its entirety. One plan might be better for one district, while another plan would be better for others. He pleaded for the financing of school buildings on a basis that will be fair and just to all concerned. As the pay-as-you-go plan eliminates all interest cost, the general trend he thinks will be in that direction.

Engelhardt, as reported in Essex's study (673), endeavored by questionnaire to find the use of the pay-as-you-go plan. He sent questionnaires to 250 cities having a population of more than 30,000. He found that 10 percent of all cities reporting used the pay-as-you-go plan in full, while 18 percent used it in part. He also found that there was a slight tendency to finance elementary schools on the pay-as-you-go plan.

Cowen (666) pointed out that the pay-as-you-go plan appears to be ideal for communities that complete the same number of buildings every year. Such a plan avoids the payments of interest on bonds. While such a plan does not earn interest for the taxpayers, as does the reserve plan, it leaves the money with the taxpayer until it is needed to pay for construction. He further pointed out that in small places where school buildings are constructed infrequently and where the creation of a reserve fund may not be practical, the financing of schools on a statewide basis would make it possible to use the pay-as-you-go plan or some cooperative fund. In case this cannot be done every effort should be made to avoid long-term bond issues. In case bonds must be issued to build a school, they should be retired by all means before the next school is built.

The trend during the past few years regarding the amounts spent for school buildings, sites and equipment, as shown by Grotz (676), has been

a decreasing one. Prior to 1925 the normal ratio of capital outlay to expenditures was 20 percent. In 1934 the ratio was only 5.5 percent, not counting allotments from the Public Works Administration. Even by counting the PWA allotments, the expenditures for 1934 were only approximately 50 percent of what they were during a few years ago. Our school building program is going to call for an increased expenditure. We must build not only new schools to accommodate the larger enrolments of today, but also to replace buildings no longer suited to their purpose.

Linn (687) pointed out many economies that can be practiced in construction. He set up definite criteria concerning: (a) building alterations and additions, (b) school building surveys, (c) the selection and purchase of school building sites, (d) the selection of the architect, (e) the importance of the educational adviser in the school building program, (f) state participation in local school building programs, (g) the awarding of the contract, (h) the supervision of the building during construction, (i) waste in school building plans, (j) waste in mechanical equipment, and (k) the educational equipment.

Summary

While the actual amount of research completed during the past few years that would indicate trends in schoolhouse planning is rather limited, the writings of school administrators, architects, and educational specialists indicate much thought and interest in the problem. Important changes are now taking place from the old traditional school to one that will be largely devoted to the problem of assisting the boys and girls to become better acquainted with their environment. Such a changed conception necessitates marked changes in the function of the entire school plant. No longer can the school be a place where the children sit quietly for five or six hours per day. The school must become a dynamic institution assisting dynamic personalities to become more wholesomely integrated with their environment. Some of the distinct trends revealed as desirable by the current literature on school-plant planning are:

1. The curriculum needs of a community determining the school plant program
2. A larger and better equipped school plant
3. An increased participation of professional educators in the planning and the execution of the school planning program
4. A more flexible and expandable school plant
5. An increased interest in national planning which has developed rapidly during the past five years
6. An increased interest in state and regional planning
7. The development of community planning
8. The local superintendent of schools assuming the responsibility in the management of the school-plant planning program
9. The construction of a more durable school plant
10. The functional use of the school plant
11. The adaptation of the school plant to serve the social, recreational, and educational needs of the community
12. The development of a simple but dignified type of architecture

13. A more efficient utilization of the school plant
14. The use of a comprehensive school survey as the basis for determining the school plant needs.
15. The wider use of the pay-as-you-go plan for financing the school-plant planning program
16. The development of a low open type of school building
17. A change in the kinds and types of equipment used
18. The expenditure of a decreasing percent of the total school budget for capital outlay.

CHAPTER X

Needed Research in the Field of School Buildings and Equipment

EDUCATIONAL RESEARCH has made many contributions to the efficiency and economy of practically every phase of education. The curriculum, methods of teaching, administrative procedures, and finance owe much to the findings of research studies. It is therefore surprising to find that so little real research has been done in the field of school buildings and physical equipment. The explanation may lie in the fact that in the past, and to a great extent at present, the process of education has been largely a sitting-at-a-desk one with the major emphasis on textbook study. As a result, buildings and equipment facilities were given slight consideration. The broadening curriculum, the more active methods of learning, and emphasis upon doing and working with things rather than merely studying books—all have focused attention upon the importance of the physical environment and the supply of materials necessary for this changed type of work.

From the standpoint of cost, it would seem that the school plant and its equipment would have attracted careful study. Table 10 gives some interesting data showing the total expenditures of all states for public education and expenditures for lands, buildings, and equipment.

TABLE 10.—TOTAL EXPENDITURES OF ALL STATES FOR PUBLIC EDUCATION AND FOR LANDS, BUILDINGS, AND EQUIPMENT, ALTERNATE YEARS, 1920-32 (714)

Year	Total school expenditures, including capital outlay and debt service	Expenditures for lands, buildings, and equipment	Percent of total spent for lands, buildings, and equipment
1920	\$1,036,151,209	\$153,542,852	14.8
1922	1,580,671,296	305,940,965	19.35
1924	1,820,743,936	388,469,143	21.3
1926	2,026,308,190	411,037,774	20.3
1928	2,184,336,638	362,996,156	16.6
1930	2,316,790,384	370,877,969	16.0
1932	2,161,170,060	210,996,262	9.8
Total for seven years	\$13,126,171,713	\$2,203,861,121	16.8

The table does not include interest payments which in the one year 1932 amounted to \$182,943,930, or 8.5 percent of the total expenditures for all purposes during that year. It will be noted that the percent of the total expenditures for public schools spent for lands, buildings, and equip-

ment since 1920 ranges from 9.8 in the depression year 1932 up to 21.3 in 1924. If interest charges which are rightfully a capital outlay charge were included for the period covered in the table, then approximately 25 percent of the total cost of public education in the United States is devoted to capital outlay and interest charges. Assuming similar expenditures for school plants in the odd numbered years, that is, 1921, 1923, etc., approximately four and a half billions of dollars have been spent on school plants in this country between 1920 and 1932, and yet comparatively little attention has been given to research study of this tremendous educational outlay.

In the National Survey of School Finance (715), the following comment was made:

Next to the expenditures for teachers' salaries, the expenditure for capital outlay is the largest single item in school cost. It is generally believed that much money is being wasted in the expenditures for capital outlay. . . . Some of the larger and more palatial school buildings today cost several hundred thousand or several million dollars, and thousands of dollars can easily be wasted in the planning and construction of only one building. For example, if one unnecessary classroom were constructed in a building, there would be a waste of several thousand dollars. . . .

There are several criteria which school officials must keep in mind in selecting school sites. These criteria are based largely on opinion rather than on research; the size of the school site, for example, is still a matter of opinion, as are other criteria. . . .

Because of the enormity and technical nature of the problem of planning, constructing and financing school buildings, there are numerous opportunities for waste. Research should be undertaken looking toward the elimination of as many wastes as possible.

In a report prepared by the United States Office of Education for the Citizens Conference on the Crisis in Education (712) are found the following statements:

The addition of new schoolrooms to house the increasing school population is being postponed during this (depression) period. Long-time building programs are being held up, and eventually enormous expenditures will have to be undertaken to bring the available housing up to the demands. In many localities, school buildings which are unsanitary and otherwise dangerous to child health and safety must continue in use. In other localities, it means that the types of instruction required to meet the changing needs of society cannot be met because of unsuitable school plants.

Comments from two men, both thoroughly familiar with the school building field, are pertinent here. Dr. H. W. Anderson, superintendent of schools at Omaha, Nebraska, and formerly responsible for the development of the school building program in Denver and Detroit, was a member of the committee which prepared the first number of the *Review of Educational Research* in the school building field. In a communication in connection with his work on this committee, he wrote, "Actual research in this field almost entirely lacking." The second comment is taken from a letter from Francis Scherer, superintendent of school buildings, Rochester, New York, who has prepared Chapter VII of this issue of the *Review of Educational Research* dealing with "Types of Construction and Materials as Related to the Original Cost, Maintenance, and Operation of School Buildings." Quoted from this letter is the following:

You will notice that it (Mr. Scherer's section) does not follow the style of the matter in some of previous *Reviews* which is due entirely to the fact that my assignment was such that reference to published works was almost impossible because of a lack of writings on the subject.

I have reviewed countless numbers of *School Board Journals* and *Nation's Schools*, together with various architectural and engineering magazine articles, but I could not get enough information to justify a bibliographical set-up.

Another member of the committee, W. K. Wilson, writing about his chapter dealing with technics for determining housing requirements in elementary schools and junior and senior high schools, commented in part as follows:

But nevertheless I managed to go through a lot of material, then made a complete digest of Smith's four volumes of bibliography from Indiana. Of the nearly 5,000 references in Smith's work, I isolated eleven which can properly be called research into that phase of school building problems dealing with planning of buildings. Only three of these dealt specifically with planning techniques. . . . I think I could write an interesting chapter on the need for further research along that line.

The earlier statement that "the types of instruction required to meet the changing needs of society cannot be met because of unsuitable school plants" is significant as an indication of the importance of the school plant to the efficiency of the educational program. Is the money spent for a modern school building justified or would a cheaper and less elaborate building do just as well? How important is the school plant to the school program, and in what features and to what extent does a building and equipment affect the efficiency of teaching? There is at present no adequate answer to these questions.

Perhaps most people would agree that there is a relationship between the quality of the school plant and the character of the educational program, but little evidence of this relationship is available. Some evidence of this relationship was found by Holy (713). In this study, 7,067 of the 7,116 public school buildings in West Virginia were distributed by type of construction in accordance with the classification of the American Institute of Architects. This classification of five types extends from Type A which includes buildings constructed entirely of fire-resistive material, to Type E which includes frame buildings. Quoted from this study is the following:

In the total educational process the school buildings, of course, are only one factor. There may be found, and probably are, many good schools operated in poor buildings and vice versa, but on the whole it seems a safe assumption that there is a direct relationship between the quality of school and type of building. Fortunately it is possible to get some objective measure of this relationship so far as the state of West Virginia is concerned. Mr. E. L. Bowman, Statistician of the State Department of Education, recently rated the fifty-five counties of the state according to the Ayres method. . . .

This relationship is rather strikingly shown in certain specific cases. For example, Ohio County, which ranks second on the basis of the few E class buildings found therein, ranks first according to the Ayres method. On the other hand, Pendleton County, which according to the above table had only E class buildings, ranks 55 or

lowest among the counties. In order to get this relationship for the entire group, the ranking by counties according to the Ayres method was correlated with the ranking on the number of E class buildings, with the county having the smallest number of E class buildings ranking first. This correlation ran + .66 with a probable error of + or - .0530. In view of the type of measurements used, this is a very significant relationship.

Obviously no general conclusions can be drawn from this relationship because there are many other factors in this situation which were not under control. Furthermore, items 6 to 9 of the Ayres Index are measures of expenditures for other than salary purposes, including those for buildings. Such being the case, there is a common factor which may in part be responsible for the relatively high correlation. Despite that, however, the facts indicate a positive relationship, the extent and character of which need further investigation.

Aside from mere opinion, no one knows how a school building or its equipment may best facilitate the activities of the school. There are a number of school building "standards" and "score cards" which have undoubtedly contributed to the improvement of buildings, but these standards are usually formulations derived largely from opinions rather than research.

It would be impossible to present here all the needed research in this field but as an indication of some of the problems needing careful study, a few are listed.

In general the problems in the school plant field may be divided into two major divisions:

First—Those problems concerned with the functional planning of school buildings and equipment to serve better the actual instructional and recreational activities of the school.

Second—Financial problems concerned with the efficient and economical construction, maintenance, and operation of the school plant.

An example of the first type is that of space provisions necessary for various school activities. State regulations for classroom space per pupil vary from 10 square feet to 19 square feet. In four junior high schools in one city the number of square feet provided for each pupil in science rooms varies from 28 to 91, in shops from 53 to 85, and in gymnasiums from 65 to 86. If 10 square feet per pupil in a classroom is sufficient, then to require 19 square feet is a tremendous waste of money. But for lack of definite knowledge, it is generally the custom to average the extremes and pronounce approximately 15 square feet per pupil to be the desirable allotment of space for classrooms.

There is likewise little definite basis for determining the amount of space which would be allowed for non-instructional parts of the building, such as corridors, toilets, offices, storage, and similar areas. Under these conditions, it frequently occurs that some parts of a school building are much more spacious than needed while others are seriously restricted. The cost of school buildings is so great as to make such haphazard planning a serious drain upon finances.

An example of the second type of problem is that of the effect which the size of building and type of construction have upon operation and maintenance costs. Approximately 15 percent of the current expenses of the public schools in the United States, or over \$250,000,000 normally go for operating and maintaining the school plant. Costs of maintenance vary among cities from 2 to 8 percent, and costs of operation from 9 to 13 percent of the total current expenditures. These wide differences are probably due to the type, size, and age of buildings, kinds of construction, materials and equipment, and the policy of the school systems in their programs of operation and maintenance. It seems reasonable to expect that many of the factors which contribute to excessive operation and maintenance costs can be isolated and in many cases ways can be found to reduce this cost substantially, especially in buildings erected in the future.

A few additional problems needing research study will be cited merely to indicate the general nature of the unsolved problems in the field of school buildings, grounds, and equipment.

1. Reliable methods of determining the room requirements for a given program. New York state has made considerable headway in meeting this problem for its own program.
2. Size of school sites. These need to be determined on the basis of the recreational program.
3. Flexibility in the design and construction of school buildings. This problem is increasing in importance due to developments in curriculum and teaching methods. A school building has a life of 50 to 75 years and unless it is of a flexible type, it either thwarts educational development or has an early obsolescence.
4. Expansibility so planned that additions can be most easily and economically made without destroying the unity of the building.
5. Factors which contribute to obsolescence.
6. Lighting, both natural and artificial.
7. Toilet requirements.
8. Studies of building utilization.
9. Location and plans of different types of rooms.
10. Best building materials, when cost and utility are considered.
11. Multiple use of rooms and equipment.
12. Acoustics of classrooms, libraries, and auditoriums.
13. Arrangement and types of equipment.
14. Effect of good school buildings and equipment on educational achievements.
15. Methods of calculating unit costs of school buildings.
16. Effect of expenditures for capital outlay upon the school budget and upon the curriculum. This question is particularly pertinent in small communities. New buildings may furnish a stimulus to the support of an enlarged educational program or there may be a tendency to pay for the new building by savings made at the expense of teachers' salaries, supplies, or other current expenditures.
17. State and city organizations responsible for the planning, erection, maintenance, and operation of school buildings.
18. School plant insurance. Ratio between premiums and losses according to types of building construction. Self-insurance plans. Effect upon insurance rates of elimination of fire hazards.
19. Continued studies of school ventilation (see detailed suggestions on page 361).

Some explanation for the relatively meager amount of research in the field of school buildings and equipment may be the fact that such studies

require unusual facilities and in many cases would necessitate a considerable outlay of time and money. It must also be recognized that the problems in this field are somewhat technical and there are not a great number of persons with the experience and training necessary to make many of the needed studies. Furthermore, many of these are engaged in administrative work and hence cannot devote the time and energy necessary to this type of research. No doubt the character of recent studies indicates that the place of adequate school plants and equipment in the modern program of education is receiving more and more attention. There is need, however, for an organized research program, adequately staffed and financed, so that there may be a continuous and consistent attack on these significant school building problems.

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Chapter IX. Recent Trends in School-Plant Planning

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Chapter X. Needed Research in the Field of School Buildings and Equipment

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